PRACTICAL FORESTRY

A Forest Scene in Oregon.

PRACTICAL FORESTRY

FOR

BEGINNERS IN FORESTRY, AGRICULTURAL STUDENTS,
WOODLAND OWNERS, AND OTHERS DESIRING
A GENERAL KNOWLEDGE OF THE
NATURE OF THE ART

BY

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WITH MANY ILLUSTRATIONS

NEW YORK
D. APPLETON AND COMPANY
1904

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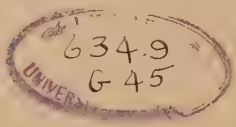

Published May, 1902

PREFACE

In the following pages the author has endeavored to include those parts of the science and art of forestry which are of interest and importance to the general reader and beginner. It has been his endeavor also to make this book as practical as possible, so that the owner of a large tract of woodland, and the farmer with his wood-lot, or the owner of a country place, or those interested in the various industries connected with forests and forest products, may glean hints of value. The greatest difficulty has been in deciding what to exclude rather than include. It is by no means easy to select from the great mass of technical and general literature on this subject those points which are of value and interest to the general reader, to the owners of woodland, and beginners in general.

Beginning with Cotta, the father of forestry, numerous writers have expressed many of these facts before, but the selection and arrangement of the contents

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are original. As far as the writer knows, no author in English, or in fact in any language, has presented the subject in the following arrangement and in such untechnical and popular yet accurate form. Forestry, when shorn of pedantry, simplified, and divested of technical details of little importance at present to the American, falls readily into place by the side of the cognate arts of horticulture and agriculture. The tendency on the part of European writers has been to amplify and extend the subject to the exhaustion of the merest detail, necessitating a long search through an immense amount of unimportant and uninteresting matter in order to find the points of most importance. In fact, the science and art of forestry have been much encumbered with unnecessary mathematics. "Mathematics must be the servant and not the mistress of silviculture." The Europeans have produced a very complex and difficult science out of one which is so simple that any man of ordinary intelligence may comprehend it.

Progress in this country is founded upon public opinion. Public opinion is dependent upon the degree of intelligence and educational advantages of the general public. The best way to educate people in a subject of this kind is to supply them with reliable literature written in plain language and available at a reasonable price. The neglect of our forests

is simply due to ignorance, which it is hoped this book may help to overcome. Whether it will be successful or not, time alone can determine.

Forestry is both misunderstood and underrated in this country. When these misconceptions are dispelled the American people will handle the subject with true American spirit. The main point, which is not generally understood—in fact the pivot on which the whole subject rotates—is that we fail to rate the forest as a living perpetual resource. Coal, copper, and other resources become in time exhausted, but the forest if properly treated will yield an income forever. It will supply labor and feed other industries for all time if the rules of silviculture are rigidly practised. In agriculture, fertilizers must be used to replace what the plant removes; in forestry, the soil actually improves and yields ever-increasing returns until the maximum is reached, when under good management it remains the same for all time, ever yielding a crop of useful materials.

No subject is of more general interest. It should appeal to everybody. It is a many-sided subject. To the man in search of health or recreation and sport, such as fishing and hunting, and to the lover of Nature, the forest has many attractions. As a yielder of useful materials, a support to many industries, and a supplier of healthful labor, it has no equal. To the

engineer it is of importance as a means of checking the destructive forces of Nature.

The host of inquiries which the author has received and the expressions on the subject by prominent educators and foresters have led him to believe that there is a definite place for such a book.

Although not primarily intended as a text-book, it may be advantageously used as a guide in secondary schools and other institutions where forestry deserves a place. It could be used to advantage in connection with commercial and physical geography. To the subject of *Forest Geography* there are four important sides, which have been treated more or less at length in this volume. The first relates to forest products and industries. This is an important branch of commercial geography with which every young man about to enter business life should be more or less familiar. The second relates to the influence the forest exerts in checking the destructive forces of Nature, the forest being, in fact, a protective blanket over the face of the earth. The third relates to the distribution of forests. It deals with those factors which produce the spread of forests and the barriers which prevent their extension. It explains the presence of prairies and deserts in one place and forest-growth in another. The fourth, which should be of great interest to geographical students, relates to our great reservations

and national parks. These reservations cover an area of about fifty million acres, a territory so large and varied that it is worthy some space in even primary geographies. They cover an area much larger than the whole of New England, three times as large as Greece, and almost five times as large as Switzerland; yet the establishment of these reservations has apparently only just begun.

The author desires to thank Dr. Joseph Rothrock, Forestry Commissioner for Pennsylvania; Dr. B. E. Fernow, Director of the New York State College of Forestry; and Prof. W. W. Rowlee, Assistant Professor of Botany, Cornell University, for many suggestions and favors.

Acknowledgments and thanks are due to Col. William F. Fox, Superintendent of Forests for the State of New York, Prof. Mark V. Slingerland, E. A. Sterling, and John C. Phillips for some of the photographs used in this volume.

If this book serves to convey practical information and to arouse interest in the subject throughout this country, and helps to produce a better treatment of our woodlands, its mission will have been fulfilled.

JOHN GIFFORD.

ITHACA, N. Y., *January, 1902.*

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PRACTICAL FORESTRY

PART I
INTRODUCTORY

CHAPTER I

MEANING OF FOREST AND FORESTRY, AND OTHER INTRODUCTORY NOTES

"The forest and water problems are perhaps the most vital internal questions of the United States."—*President Roosevelt.*

Forestry treats of the formation, care, purpose, and utilization of forests. It is founded on the natural sciences, the most important of which to the forester is botany. Forestry is primarily an art, or the skilful application of knowledge gained from many years of experience and experimentation. The purpose of a forest may be to check the destructive forces of nature, to yield timber and other products, or to beautify the earth. The term utilization relates to the process of harvesting, converting, and disposing of forest products. A forest is something more than a mere clump of trees. It includes not only trees, but other plants and many animals which play parts of more or less importance for good or bad.

A forest is a community or society of living things, the most important of which is the tree. The forest is a unit or organized whole consisting of three distinct parts—the canopy, the floor, and the wood-mass. The forester speaks of an assemblage of trees as a stand. The stand may be young or old, good or bad, thin or crowded, mixed or pure, regular or irregular. A pure stand consists of one species of trees, a mixed stand of more than one. In a regular stand the trees are all about the same age and size. In an irregular stand there is no uniformity. The forest canopy and forest floor are interdependent. The forest canopy protects the forest floor, and, in turn, upon the vigor and healthfulness of the canopy depends the nature of the forest floor. Upon the quality of both depends the rate of growth, and upon the rate of growth depend the quality and quantity of wood production. Animals such as earthworms loosen and ventilate the soil; bees, in many instances, fertilize the flowers and thus increase the seed crop, and in consequence the number of young trees; toads, bats, birds, and other animals keep in check injurious insects; and countless toadstools, puffballs, and other fungi hasten the decomposition of the leaves and sticks on the forest floor. The forest is a mass of living, struggling organisms. Hundreds of forces are at work for good or bad, to be restricted or favored by the forester for

the production of such conditions that the forest may grow to the best advantage for the purpose intended.

Forest-culture, forestry, and silviculture are practically synonymous terms. The term "silva," in Latin, means forest, and in English is applied also to the forest-trees collectively of a region. We would say, for instance, that "the silva of the Pacific Coast consists mainly of conifers, or cone-bearing evergreen species, such as the redwood, pine, and spruce." The term "silva" is also applied to a descriptive list of the forest-trees of a particular region or country, as Sargent's Silva of North America. The term is in common use in the adjective "silvan," in the term "silvas," which are large wooded areas in South America, and in the proper names Pennsylvania and Transylvania. The term "arboriculture," from the Latin "arbor," a tree, is applied to the growing of trees for any purpose and in any way whatever—singly, in groups, or in the form of forests. Silviculture is therefore a part of the broader art of arboriculture.

Forests may be grown for other purposes than timber production, such as protection and adornment. Although, perhaps, the most important, wood is not the only important forest product. In the case of rubber or camphor, the wood is of minor importance.

The growing of forests for timber is often called timber-culture. This term has been extensively used in this country, especially in connection with the timber-culture acts of Congress, which granted land to the prairie settler on condition that he plant a specified portion of his tract in trees. These acts are no longer in force, but the term timber-culture is a good one for that part of silviculture in which timber production is the principal object.

The terms timber and lumber are used in a peculiar way in this country. Lumber usually means sawn or hewn stuff in merchantable form and of the smaller dimensions. The term timber is applied to the forest in the sense of standing timber, and to hewn or sawn stuff of the larger sizes, such as the timbers of a barn or of a ship. This use of the term lumber is peculiar to America. In Europe it refers to disused or discarded goods of any kind, and according to some authorities, is a modification of the word "Lombard," the Lombards having been in early times famous pawnbrokers. In England the words timber and wood goods are common. It is said that the American use of the word lumber originated in Boston, which was once a great lumber-port, because the lumber-merchants "lumbered" the wharves and streets of that city with their product.

Another common Americanism which is loosely

applied is the word stumpage. It ordinarily means standing timber considered with reference to its amount and value for cutting, so called because the amount cut is ascertained by counting and measuring the stumps.

A "virgin forest" is one in which there has been no cutting. It refers to natural and not planted forests. The term "second growth" is variously applied, but usually refers to forests which are not virgin, and which have not been planted.

The German term "forst," the French "forêt," and the English "forest" have for many years implied care and protection. The removal of forests, without regard for their regeneration, is called deforestation. The formation of forests on deforested areas is called reforestation. The French word "reboisement," which means the same as reforestation, is sometimes used in English. The French "bois," the Spanish "bosque," the Italian "bosco," the Dutch "bosche," the German "busch," and the English "bush" are probably all different forms of the same word. The term bush in the sense of woods is used in this country in the word "sugar-bush." A forest with undergrowth is called "the bush" in South Africa, Australia, and Canada. The term "scrub" is used in the same sense in Australia. A woods choked with underbrush is often called a "jun-

gle." The term forest is seldom used by woodmen in this country. Good or bad, big trees or bushes, it is all called woods, which is a good generic name for such nondescript lands.

The forester should always have in mind the future crop. He should cut always with a purpose other than the mere reaping of the wood. He should consider the young promising growth which becomes the forest of the future. The keynote of forestry is perpetuity. Were one to enter the forest and cut only the best trees each time and leave the rest, this would not be forestry even if the operation were conducted with great care. Were one to enter a forest and cut only those trees which are over a certain diameter, this might and might not be forestry. If the forest consists of species of unequal value, the removal of the best would lead to the deterioration of the stand. The forest weeds or undesirable kinds of trees would be thus constantly favored. Although this is, perhaps, better than the common method of lumbering, it is like removing the ripe vegetables from a garden without disturbing the weeds. If there are no weeds in the garden, and no danger of weeds, this would be permissible. In forestry, one must have the future in mind, and the forester must work constantly for the proper maintenance of the soil and forest. If one has an irregular forest of

spruce or pine, or any other species, or several species together, if they are of equal value, and then follows the rule of cutting only mature and undesirable trees, he would be practising forestry. By irregular forest is meant a forest consisting of trees of all ages. Were one to cut his forest clean, and plant it afresh, he would be practising forestry. Were one to cut his forest in such a way that sufficient seed trees will be left, and care for it in such a way that only desirable kinds will be allowed to grow, he would be practising forestry. In remote districts, however, a poor system is better than none, and in many instances our ideals must be sacrificed to meet existing conditions, so that if the forest is merely protected from fire much is accomplished.

In India, for instance, where forestry is well under way, as much is done as we can hope to do for some time in this country. This is well expressed in the words of Ribbentrop in his Forestry in British India: "All we can, in the majority of cases, succeed in doing, is to protect our forests as much as possible against fire, grazing, and other harmful interference, and to exploit them in such manner as to give natural reproduction the best possible chance, and to assist the regeneration of the natural forests by such silvicultural measures as the circumstances of each case may demand."

As Dr. Fernow says in his brochure on the Progress of Forest Management in the Adirondacks, three primary essentials must form the basis of an American system of forestry. They are as follows:

I. Better protection of forest property, including methods of taxation—a subject for legislation.

II. More thorough utilization of the forest crop—a subject of wood technology and development of means of transportation and harvesting.

III. Silvicultural methods of harvesting, so as to produce a desirable new crop, or else artificial reforestation, if that is more effective and cheaper—the main concern of forestry. These three phases of the subject will be treated more or less at length in the following chapters.

In this country, owing to the great abundance of wood in times past, and owing to the difficulty of enforcing laws in thinly populated forest districts, the forest has been abused. This is so in most new countries, such as Canada, United States of America, and Australia. In speaking of the destruction of forests in Australia for the sake of pasturage, the historian Froude says: "Trees so nateless ought to be preserved, but the soil which bears them is valuable, and they are doomed to destruction. Government makes law, but in a democracy the people do just as they please. Greed and practise are master; the laws

are only paper." This, no doubt, is in part true. It is, however, not the fault of the democratic form of government. It is due to the fact that the people which constitute it are not equal to it. After all, what is the State in America? It is simply an organized community, the ruling powers of which are only persons which the people have chosen temporarily from their midst. The purchase of forest land, the management of forest land, or the sale of forest land depends upon what the majority of legislators may think best, and they, in turn, are supposed to comply with the wishes of the majority of their constituents. The wishes of the majority of the people in reference to the forest depend altogether upon their education and character—in short, public opinion, which is molded by our various means of education.

Every honest, well-informed man who believes in government will agree that the State is doing nothing more than its duty when it does the following on the grounds that the forest is necessary, first, because of the protection which it affords, and, second, because of the industrial importance of the products which it yields:

1. Each State should own and control those districts where forestry can not be properly and profitably conducted by private parties.

2. The Federal Government should lend a helping hand, and, in addition, own and control large reservations and parks in those parts of the country which are noted for their beauty or natural wonders, and which, for other reasons, are of more importance to the country as a whole or to a large area of the country than to the State or States in which they may happen to be located.

3. Both the State and Federal Governments should cooperate with the private owner in many ways to inform him in reference to forestry matters, and to encourage and induce him to treat his forest land in the proper manner.

4. This cooperation may be applied in several forms, the most important of which are the following:

By the extinguishment and prevention of forest fires; by the construction of roads and fire-lanes; by the establishment of schools of forestry and chairs of forestry in agricultural colleges; by the establishment of forestry experiment stations and model forests; by fair taxation; by giving information on the subject to all who may desire it; by the distribution of literature on the subject; by the introduction of valuable species from foreign countries; by the establishment of seed-testing stations; by the distribution of seeds and young trees to those who will care for them; by the establishment of lecture courses to

the people in connection with agricultural and horticultural meetings; by aiding in the eradication of insect pests; by encouraging the preservation of beneficial animals, such as birds and toads, and by aiding all worthy associations and societies which may have these objects in view.

CHAPTER II

WOOD-LOTS ON FARMS, FOREST ESTATES, AND THE RELATION OF SILVICULTURE TO THE KINDRED ARTS OF AGRICULTURE, HORTICULTURE, AND LANDSCAPE GARDENING

"The preservation of our forests is an imperative business necessity. We have come to see clearly that whatever destroys the forest, except to make way for agriculture, threatens our well-being."—*President Roosevelt.*

Silviculture, agriculture, and horticulture blend to such extent that separation by hard and fast lines is impossible. Although the spheres of each are fairly well-defined, they often overlap or are purposely combined with mutual advantage. Many claim that silviculture is a branch of agriculture, and that the main difference between the two is that an agricultural crop is available every year, while a wood-crop, although formed every year, is not available until the trees reach merchantable size, which often covers a period of more than a century. Another difference, it is claimed, is that "culture" in agriculture implies stirring and loosening the soil, while in silviculture it merely means the bestowal of skilful labor on the forest in many ways, for the pur-

pose of aiding and improving growth. These distinctions, however, are much more apparent than real. The fact that it often requires a century to produce a fine grade of timber does not imply that a forest, when planted, yields nothing until maturity. A spruce forest at first may consist of thousands of little trees per acre. At the end of ten years it should contain not more than 4,000 trees, at the end of twenty years 2,000, at the end of forty years 1,000, at the end of sixty years 500, at the end of eighty years 350, and at maturity (one hundred years) 250. Thus in ninety years fifteen-sixteenths of the number of trees and a large volume of wood have been removed from time to time by a careful system of thinning, yielding material of ever-increasing value as the forest grows older. In the case of irregular forests, which are forests consisting of trees of all ages mixed together, managed according to the selective system—that is, cutting here and there throughout the forest whenever trees are mature or whenever for the good of the forest their removal is prudent—an amount depending upon the size of the forest and the rate of growth may be cut every year, or every now and then.

There may be, therefore, with forest as with agricultural crops a small but frequent yield. In the method of culture there is apparently a great differ-

ence, but the ends attained are practically the same. The farmer carefully tills the soil to pulverize and loosen it, and to prevent the growth of weeds. A layer of well-tilled soil on the surface and a mulch or layer of humus have practically the same effects. Instead of tilling the soil, the forester increases its moisture content and porosity by encouraging the formation of humus. The roots penetrate to deep layers of the soil for food material, much of which is deposited on the forest floor in the leaves, twigs, and wood. This material rots, and in rotting forms food for the roots. In this way the fertility of the forest soil is maintained, and, in fact, increased without the application of manure. Weeds are kept in check by regulating the quantity of light which filters through the forest canopy, and although there are weeds which endure shade, these are usually not aggressive. The growth of trees which have been planted in rows may be increased surprisingly by cultivation and application of manure, as with corn, especially in youth. In fact, in the tight soil of the Western plains cultivation is necessary until the trees reach such a size that their canopy prevents the growth of grass and protects the soil. By the "plains" is here meant the territory east of the one-hundredth meridian. West of this line, extending to the Rocky Mountains, are the "prairies."

The treelessness of the plains is due mainly to the fineness of the soil, or to fire and grass, rather than to a lack of moisture. After trees are once well started in the plains district, by careful cultivation they grow almost as well, if not quite as well, as in Eastern regions.

A crude kind of silviculture may be practised in all regions where wood will grow and where wood has value. Wherever measures are employed to insure the regeneration of the forest, there silviculture begins. The leaving of seed trees is the first step. The great difference between lumbering and forestry is that in one there is no concern whatever for the young growth and the future forest, in the other there are always other objects in view than the mere reaping of the wood-crop. Intensive systems of management, however, belong to thickly populated agricultural districts. Silviculture is the consequence of agricultural and industrial development. Some of the most productive and best managed forests of the world belong to large cities. In a thickly populated country, more or less isolated from other countries, forestry pays well, even on good agricultural soil. Soils may be divided in this regard into three distinct classes: The first, those which are so rocky that agriculture is impossible; second, such sandy soils as exist in vast quantities in our South, where forestry and

agriculture may be combined, but where a large proportion of the area should be kept in forest; and, third, good soil, which is mainly agricultural, but where, in parts, forestry may be practised with profit. There are, then, absolute forest soils, soils mainly agricultural, and soils mainly forestal.

True waste-lands include all those soils which are incapable of producing crops of any kind without reclamation.

Saxony, in Germany, has an area of 1,499,300 hectares (5,800 square miles), with a population of 3,500,000 people, with an average of 603 per square mile; 27.4 per cent of this country is in forest, mostly spruce. The little trees are raised in nurseries, planted carefully, thinned from time to time, and finally, at the end of eighty years, cut clean. Then the area is planted again, and so on for centuries. This system of procedure is not essentially different from the production of an agricultural crop. The growing of willows for basketry is practically an annual agricultural crop.

Several farmers in the plains district of our West have planted trees and reaped a handsome profit from fuel-wood and fence-posts in a few years, and have, at the same time, protected their orchards and produced fruit which would have been impossible without the shelter which the trees afforded.

Southern California has been completely changed in appearance by the planting of exotics, especially species of the genus *Eucalyptus*. This has been all due to the efforts of individual farmers. When the swampy lands of Gascony were reclaimed by tree culture, a new province was practically added to France.

Many claim that individuals can not be expected to plant trees for timber, because life is too short, and the investment, which is increasing at a rapid pace by compound interest, is too long unavailable and too slow in producing returns. In the North, where growth is slow, this is, perhaps, so, but in the South merchantable timber can be produced in much less time. Short rotations, and by rotation is meant the length of time from planting to reaping the crop, bring forestry within the means of the farmer. It is true that the State should own those forest areas which are needed for protective purposes, but it is Government cooperation, as in road construction, that is needed, as much as State ownership or State control. Let us hope for the time when our people will be educated to a point where they will care for their own forests as well as, if not better than, the State can ever do it, and with such willingness that coercion would be both unnecessary and pernicious. The more civilized people become the more they work

for the good of the community and of posterity. Some day men may have the same interest in the landscape in general that they have in ornamenting their own homes. At any rate a very large proportion of our forests are destined to remain in private hands. The Government will be doing a very great deal, and infinitely more than it does at present, when it properly protects a man's person and property from the carelessness and maliciousness of others, when it taxes property in a fair manner, when it owns and controls those forests necessary for protective purposes, and when it gives to its people all the information, gratis, they may desire in reference to the management of their lands. The ill treatment of forest land is due very often to ignorance. In many cases the owner of the land knows no better. There is no more reason why a farmer should knowingly ill-treat or neglect his woods than his corn-field. Farmers in many parts of this country to-day could and would grow locust, poplar, chestnut, spruce, and other trees with profit if they knew how. The Bureau of Forestry at Washington is doing good work in encouraging individual efforts in this line. Every State, in fact, should have a division of forestry to investigate, experiment, inform, and advise all those who are in need of help. Merchantable white pine has grown in Pennsylvania on poor soil without man's

help in any way in thirty years. Large timber can not be produced in that length of time, but merchantable materials, such as are now used in the sawmills of the Eastern United States, are often considerably under that age.

The wood of some trees, such as white pine and walnut, must be old to be good; in others, such as hickory and locust, young wood is quite as good, if not preferable.

Posts and poles which may be utilized on the farm can be produced in ten years. In Germany the spruce thinnings, which are peeled and then soaked in preservative solutions, are extensively used in fence construction.

In the Old World forestry and agriculture are combined. It is very common in Germany and France to see a field of wheat and basket willows side by side. It is not uncommon to see potatoes and other crops between the rows of little trees, which are destined to form the future forest. Often the seeds of trees are sown with a crop of grain. The grain protects the young trees and pays for the cost of seed and soil preparation. In France, cuttings of poplars are stuck in the ground along streams and roads. In the course of a few years the side branches are cut off. These are tied into bundles and sold to bakers. They are in great demand, because they give

a quick, hot fire, and produce a thick, rich crust on bread and pastry. In the course of about twenty years these poplars are cut and sawn by hand into boards, often by the very man who stuck the cuttings into the soil. The same is so of the willow throughout Europe, especially in the Low Countries, where the twigs yield fuel, withes for basketry, wood for sabots or wooden shoes, and all the while the roots are holding the soil in place along their boisterous rivers.

In Italy, where there is an abundance of sunshine, the fields are planted with rows of trees, between which a crop of grain or potatoes is planted. These trees consist of olive, walnut, willow, poplar, and mulberry. They are extensively cut back or pollarded, and serve as props to grape-vines. The willow yields twigs with which to tie the vines, and the loppings furnish fuel. The leaves of the mulberry furnish food for silkworms. The leaves are often pulled off and put in a silo in the ground to furnish fodder. Thus, an acre of land produces grain, olives, nuts, grapes, fuel, twine, wood for constructive purposes, and even fodder.

As one moves southward, the possibilities of combining silviculture and agriculture increase, until, in fact, in many instances, it becomes a necessity. There is such an abundance of sunshine in the tropics that

many crops demand shade, so that forest-trees are used for shelter or nurse purposes. In the North, the light of the forest is transmitted through the tender leaves of the trees. In the tropics it is more or less reflected from their shiny surfaces. One tree has been used so much to shade the chocolate that it is called "the mother of the chocolate." In Porto Rico and Mexico one could pass through a coffee plantation without knowing it. The coffee is planted in the shade of the forest, which has been thinned and cleaned. In Mexico a row of coffee- and a row of rubber-trees are planted. The rubber soon shades the coffee, and both are protected in early youth by a crop of cassava, bananas, or corn. The overwood, in many instances, could be a timber producer. In Java the teak is planted, and between the rows field crops are grown. The workmen, under a cooperative plan, are allowed the field produce by the Government, and a premium is given in proportion to the growth and prosperity of the teak-plants. This is an interesting cooperation, where the state owns the land and where the natives do the work and reap a reward proportionate to their efforts. Professor Knapp, in his report on the Agricultural Resources and Capabilities of Porto Rico, says: "One of the most serious obstacles confronting the agriculturist in Porto Rico is the scarcity of timber and wood. . . . This

scarcity of timber accounts for many things. It renders it almost impossible to erect or maintain creditable farm-buildings in the interior, especially where there are no good roads. It renders it necessary to construct the cottages of the laborers of bark and poles. It precludes the fencing of the farms into suitable fields for keeping the variety of stock best adapted to the conditions, and yielding the largest profits to the farmer."

In Perigord, in France, forests of oak are planted for the truffles which grow upon their roots. The truffle is a fungus not unlike the potato in appearance. It is relished as a food, and, it is said, three million dollars' worth are annually exported.

On the eastern shore of the Chesapeake, forestry and agriculture are combined in a praiseworthy fashion. The pine straw is carefully collected, spread evenly, and turned under, for the production of sweet potatoes. The absence of litter on the forest floor prevents fire. In the course of time old fields are abandoned and new fields cleared. Where were formerly potato fields, young pines soon appear, and where were once fine forests are now potato fields.

Even pasturage in the forest may be practised if properly conducted. A couple of cows in the woods would cause less damage than the same number of deer. In fact, after the forest reaches an age

so that the trees are above the heads of the cattle, they may be of service in keeping down weeds.

The maple sugar and sirup industry is truly a farmer's industry. In the Northeastern United States the maple-tree forms a very conspicuous proportion of the farmer's wood-lot. From the thinnings and trimmings he secures fuel, and in summer the cattle are permitted to enjoy its shade and feed upon the grasses and bushes which are abundant upon the forest floor. The sugar-bush is usually an open forest in which there is a strong tendency toward brush and weedy growth. Cattle may often do good service in keeping it in check.

The European farmer, by raising a few basket willows on his farm, provides work for a member of the family who has learned the trade of basket-weaving, and for another member who devotes himself to selling the wares. Trunks, wagon-bodies, hampers, large urn-shaped baskets in which fish may be kept alive in the water, furniture, fike-nets, traps, poultry crates, and a host of useful objects are manufactured from willow twigs.

Unfortunately, a tree on a farm is too often a convenient place for tying horses. Into it nails are too often driven. These become in time covered, and are found later embedded in the wood. The tree ordinarily serves as a place to rest old rails against,

and to shelter old wagons and worn-out machinery. Trees in this way are seriously injured, and so riddled with iron that it is impossible to saw them into boards; in fact, unfit even for fuel, because of the injury to axes and saws in working them. Trees are too valuable to be used in this way. The life of a tree may be prolonged many years by giving it a little care. It is surprising the large number of trees which are thus thoughtlessly crippled or injured.

Silviculture is of special importance to farmers for the following reasons: First, the forest yields fuel, wood for constructive purposes, litter, and other material of use to every farmer. Every now and then a farmer cuts a stick from his wood-lot for a fence-post, for a vine or tree prop, for an ax-handle or swingletree, as a matter of course. Were all the materials yielded by the wood-lot counted at their full value, I believe the wood-lot would be rated the most important feature of the farm. For a large portion of the year at least, wood is the common farm fuel. The fence problem is also an important one, and the farmer who produces his own fence material saves a very important outlay. The fences on a farm often represent a larger cash outlay than the land itself.

Second, these materials, over and above what the farmer may need for home consumption, may be sold to good advantage. In that way he may earn

something when there is little else to do. In many instances fuel-wood is sold for about what it costs to cut and haul it. Although in such cases a man may get nothing for his wood, he gets paid for his work. The woods are a means to an end.

Third, poor land on a farm may be used to better advantage for forest than for any other purpose. Even in very fertile districts there are few farms without some uncultivable land. Land which is extremely dry or wet, or rocky or sandy, or land subject to washing, should be used for forest.

Fourth, a farmer is in position to make his forest yield a larger income than any other kind of proprietor. Supervision costs him nothing. He works in his woods when he has little else to do. He has his own teams, and usually his own boys to do the work.

Fifth, forestry and agricultural pursuits may often be combined, to the advantage of both.

Sixth, the forest improves the quality of the soil.

Seventh, the forest is a protection against the destructive forces of nature.

Eighth, the forest adds variety and beauty to the landscape.

Ninth, the presence of forests, by yielding useful materials, renders possible the presence of other industries. These are not only sawmills, but wood-alcohol establishments, pulp factories, box factories,

kindling factories, and a host of small industries which thrive in the presence of an abundance of wood.

The majority of people have a strong desire to possess land. There is a gratification or pleasure in

A Southern Pinery.
A scene near the Chefuncte River, La.

mere possession. It is in this way for a comparatively small sum that a rich, busy man may secure seclusion and rest. Our forest lands have been mangled to such extent by lumbermen that one must travel many miles from the centers of population to find the true wilderness. It will soon be so that every man must own a resort in order to secure

the pleasures of the woods. The purchase of vast forest estates by wealthy men should be encouraged. The country is rendered more beautiful, and surrounding lands are in many ways benefited. Much of our waste mountain land must come ultimately either into the hands of the State or of wealthy persons. The influence of one large, well-cared-for estate is felt far beyond its boundaries. An example of this kind was set by Mr. Vanderbilt at Biltmore. Others have followed, and as time goes on they will increase in numbers. On each of these estates there is place for a well-trained forester who knows something also of landscape art, of road construction, and surveying. In the British Isles and on the Continent of Europe there are thousands of such estates, many of which yield handsome returns in dollars and cents. The purchase of forest land is often practised for purely business reasons, in order to secure a permanent investment. It is, as Romero of Mexico once said: "Everywhere the world over the man who gets the lands and holds on to them is the wealthy man. Speculators and financiers come and go like bubbles on a river, but the landed proprietor keeps a permanent clinch on humanity." Two classes of proprietors are not worthy of consideration in this connection. First, the speculator who buys land to sell again without improving it, and, second, the man

who buys land to strip it and then to desert it. We are only concerned with those persons who have permanency in mind, those persons who own property in the country for the pleasure it affords them or for the income which it yields. For the sake of convenience we may classify owners into, first, those who own farms with wood-lots, and, second, those who own large areas of forest and a small proportion of cultivated land. The latter may be called forest farms. Owners may be classified also according to purpose. The first includes all those cases where pleasure and not income is the controlling factor. In such cases there are legitimate returns, but they are not in the form of dollars and cents, and are difficult to measure. In the second class, income in money is the controlling factor.

Forests for pleasure may be usually divided into two classes: First, those which give pleasure because of their beauty, and, second, those which give pleasure because of the game which they contain. Although these two may be easily combined, the constitution of the forest must be modified for game. There is usually much difference between the form of an esthetic and a commercial forest. In a commercial forest the trees are often set in rows with mathematical precision. It is the same throughout. A forest, to be beautiful, must be wild and varied. The plants

which constitute it must not be stiff and formal. It is, as Professor Bailey says, "Not plants which make a place attractive, but the arrangement of plants." Landscaping is the production of naturelike effects.

The landscape must be full of variety, interest, and beauty. There must be nothing that shocks or jars our sensibilities. These shocks are usually produced by man's interference, and can be remedied by the application of skill and money. There should be no sudden interruptions. If there are changes from one forest form into another, they should blend. There should be openings here and there in the forest in the form of juicy, well-kept meadows, fringed with wild shrubbery. This shrubbery should give way gradually through several height stages to the high forest in the background. There should be openings, glades, and clean broad vistas here and there. Conifers should be sprinkled here and there with the hardwoods, and often in groups with a clean moss or leaf-covered floor. They give many shades of green in winter, and there should be a generous mixture of broad-leaved trees to give color in autumn. There should be no dead trunks, stubs, or stumps. The forest should be irregular, and managed according to the selective system, which is described on another page. There should be as little coppice as possible. Mixed seedling growth is preferable. Rank coppice,

sprouting from stumps, is seldom pleasing in appearance. Open groves and glades here and there are pleasant. Bold cliffs and rocks should be left bare, and the forest should be cut from places which may command broad views or beautiful vistas.

Roads and paths should be abundant, to make the scenery accessible. These roads should have slight grades, and should wind round rather than cross over hills, wherever possible. The trees should arch over the road, and vistas from the road over valleys of foliage should be as frequent as possible. The roads should be well-rounded and well-ditched along the sides. Dirt roads, in most countries, are excellent where the drainage is well arranged. The bridges should be rustic, and rubbish should be removed from the ponds, springs, and streams. Now and then an artificial pond might enliven the landscape. There should be no bare embankments along the roads, and wild flowers should be encouraged to grow by the wayside. The types of wild vegetation should be studied so that each community may have its full complement of members. Every kind of soil depending upon exposure, elevation, and moisture conditions has its community of individuals. If one or more is, by accident, missing, the group may be enlivened by additions from neighboring communities. In short, a very shabby landscape may become a beautiful scene

when the blemishes have been removed. Possibilities of improvement are of course fewer in some flat countries, especially those lacking streams and lakes.

In regions where game is desired, the problem is simple, although its execution is difficult. There must be adequate fences, and much watching is often necessary to prevent trespassing and poaching. Those plants which yield food material for game and that composition which insures shelter in winter are necessary. The remorseless hunter and hound and other destructive agencies must be kept in check.

In Europe the deer are practically domesticated, and feed, as do cows, without concern on the farmers' fields and along the wayside.

From a business standpoint a forest may yield a revenue from the sale of hunting rights for specified lengths of time with restrictions as to the quantity killed and manner of killing. A revenue may be yielded by the sale of flesh or pelts. In many of our cold, out-of-the-way forest districts, the production of animals for their pelts may develop into a remunerative industry. Already on several islands in the neighborhood of Kadiak, the Alaska Commercial Company is exploiting the arctic blue fox with success.

Many other subsidiary industries of a similar nature may be practised in connection with the forest

which will not mar its beauty, but will add interest and help defray the cost of operation. Semi-wild turkeys are in high repute on such estates. They grow fat on the nuts of the forest, their meat is improved in flavor, and they help to keep in check injurious insects.

In the forests of mild climates there is excellent opportunity for apiculture. The flowers of the linden, tulip-tree, eucalyptus, and other species yield honey in abundance, and of good quality, and the bees do good work in fertilizing the flowers.

The collection of tree seeds, if properly conducted, should yield good returns. This is an important industry in the Old World. The seeds of many species of American trees may be secured much more easily from trees growing in Europe than in this country. The seeds of some of our commonest species, such as the red pine of the North, are difficult to obtain in the market, and are very expensive.

In fact, even forests which are managed for their beauty and the pleasure which they afford, may, if properly exploited, yield something of value in dollars and cents. In this, however, as in everything else, more depends on the energy and ability of the man in control than upon the nature of the property itself.

CHAPTER III

THE FOREST CANOPY—FOREST FLOOR AND WOOD-MASS

"The fundamental idea of forestry is the perpetuation of forests by use. Forest protection is not an end of itself; it is a means to increase and sustain the resources of our country and the industries which depend upon them."—*President Roosevelt.*

The bole, or trunk of a tree, divides and subdivides into branches and branchlets, which bear the leaves, flowers, and seeds. This upper portion of the tree which bears the leafage and inflorescence is called the crown. When growing singly, in the open, the crown is wide-spreading, often beginning on a level with the ground and extending upward in a more or less spherical or conical form to the tip of the tree. In such a tree the wood is proportionately large in quantity, but poor in quality, because of the presence of knots, due to the limbage on the full length of the trunk. Such a tree, although beautiful in form and well-fitted for park and landscape work, where adornment is the controlling factor, is what the forester usually endeavors to avoid.

As has been already explained, the single tree is not the unit with the forester. He deals with an

assemblage of trees, and his unit is at least a small group or hurst. For example, let us imagine an acre of land over which we have sown the seeds of pine. Let us imagine that these have germinated and grown so that the crown of every little tree has met the crowns of its neighbors. The thicker the trees the sooner will the branches of their crowns interlace, and there is then formed a canopy. As the little trees grow, there is a struggle for room. The weaklings are unable to hold their own. The strongest push upward into the air in quest of light and room. Soon there are those which are dominant, and those which are suppressed and dying. The forester, by a careful system of thinning, endeavors to maintain a uniform canopy, so that it will rise in a zone gradually higher each year as growth proceeds. The density of the canopy is so carefully regulated that the number of trees in the forest is in due proportion to their size, so that the quality and quantity of wood are always in the highest degree. In order to produce a fine quality of wood, the shade must be regulated so that the lower branches are shed while still small in size as the canopy moves upward with the height growth of the trees. The ideal canopy is an unbroken whole—in fact, the forest on the acre referred to is not unlike one great wide-spreading banyan tree with hundreds of trunks. In a rough, irregular forest there

are, of course, many interruptions in the canopy. As forestry is applied a more uniform canopy gradually develops. For example, a wide-spreading primeval tree, having reached maturity in the natural woods, is removed. In its place hundreds of seedlings appear. These form a group or hurst, with a canopy. Several groups may often be united, or the same group extended to meet other groups by planting, so that in time a uniform canopy may be developed over a considerable area.

Owing to the fact, however, that some species need less light than others, there is a strong tendency toward irregularity of canopy in mixed woods. Trees, in this respect, may be divided into three classes—light demanders, shade endurers, and shade demanders. The fact that some trees are shade demanders in youth and light demanders later adds to the difficulty in caring for woods in proportion to the nature and extent of the mixture. This relation of species to light causes a differentiation in the nature of the canopy. The canopy may become, therefore, compound or storied. On the top is that story of the canopy which belongs to the light demanders; next, the story which belongs to the shade endurers, and also, in the tropics, where light is abundant, a story of shade demanders. Nothing is more important to the silviculturist than a knowledge of the light re-

lationships of the various species with which he is dealing. On the control of the nature of the canopy depend the success and future condition of the forest.

The canopy has several functions, the most important of which is the fixation of carbon. The great bulk of the material which we call wood comes from the carbon-dioxid of the air. When wood is burnt, the part which burns comes from the atmosphere; the rest, represented by the ashes, comes from the soil. The conversion of the carbon-dioxid of the air into starch is the work of the leaves and green twigs of the canopy. This is only accomplished in the presence of sufficient light, warmth, and moisture. The moisture comes from the soil, and is supplied by the rootage of the forest. The second function of the canopy is in shading, protecting, and manuring the forest floor. By shading the forest floor in sufficient degree, the growth of weeds, especially light-demanding weeds, is prevented. The drying action of sun and wind is also prevented. The forest floor is protected also against the leaching and pelting force of heavy rain. Regeneration, or the growth of young trees on the forest floor, is prevented until it is desired, and then it is accomplished by letting in the light which stimulates seed production by the mother-trees, and permits germination on the forest floor. One of the most important functions of the canopy,

however, is in furnishing each year a deposit of leaves and litter upon the forest floor. This disintegrates, enriches the soil, and thus hastens growth. It is in the canopy, and usually the upper part, where inflorescence occurs, and a seed-crop is produced. This occurs usually at regular intervals, depending upon the species and the condition of the forest. These years are known as seed-years.

An ideal forest consists of an evergreen conifer, such as the white pine, for an overwood, with a deciduous broad-leafed species, such as the beech, for an underwood.

By the forest floor is meant not only the surface of the soil and surface covering, but also that part of the mineral soil which contains the rootage. Trees usually prefer a soft, well-drained, but moist mineral soil, on the surface of which there is a layer of decomposed litter, or leaf-mold. The formation of humus, or leaf-mold, is called humification. It is a process of decay or disintegration in which soil fauna and fungi play a very important rôle. Nothing is of more importance to the forester than a knowledge of this process. Upon it soil fertility depends, and upon this depend the future forest and the amount of wood production. Besides furnishing food material, and especially nitrogen, which is essential to plant growth, the humus on the surface forms a

mulch, which protects the mineral soil from the destructive action of sun and wind. This humus must be of the proper nature, and must disintegrate in proportion to the amount of leaf and litter fall. It must not accumulate in immense masses, such as the peat or duff beds of the North, but must decompose into materials of such a nature that the roots may be constantly and regularly fed during the growing season. This decomposition depends upon warmth and moisture, but also, however, upon the bacteria and fungi, as well as animals, which live in the soil. A peat-bed in which these are not present is sour and unproductive.

The root-fibrils absorb the moisture of the soil in large quantities. This moisture passes through the tree and evaporates from the leaves. Water is the vehicle which carries the mineral materials which the tree requires in the process of growth. These mineral matters are often in very dilute solution, so that the amount of water thus used is immense. In the process of food absorption by the root-fibrils the tree is often, if not in the majority of cases, aided by the fungi in the humus, which attach themselves to the roots. This is a sort of mutualism called symbiosis. In the case of the alders and leguminous trees, nodules of bacteroids are much in evidence, while with the beech, spruce, and other trees the

mycelial hyphæ of fungi in the form of fine filaments attach themselves to the root-fibrils of the tree, and in some way aid the processes of nutrition. Masses of united rootlets and fungal hyphæ are called mycorrhiza. The edible portions of the subterranean fungus, called the truffle, are mycorrhiza attached to the roots of oak-trees. The materials absorbed by the roots, together with the substances elaborated by the leaf from the atmosphere, are manufactured by the protoplasm of the tree into more protoplasm and a host of other complex substances, but the most varied and most interesting, and the commonest of all, is wood, with which we are all familiar, and with which the forester is most concerned.

Although there is considerable wood in the limbage, the bulk of good material is, or should be, in the boles or trunks of the trees. Beginning with the outside of the tree, there is, first, the dead outer bark, then the living inner bark, then the sap-wood and heart-wood, and finally a little pith in the center. The wood of the tree may not always be divided into sap-wood and heart-wood. It is often homogeneous throughout. The increase in the size of the tree trunk is produced by the addition of layers of wood. The cambium tissue, which is a zone of active cells between wood and bark, proliferates or grows in such a way that as a layer of bark is formed on the outside,

a layer of wood is formed on the inside. In parts of the tropics, where growth is constant and where nothing occurs to interfere with the continuity of growth, this process of wood formation is a continual performance, and a wood is produced which is remarkably uniform and homogeneous in nature, although I know of no wood entirely free from rings or grain. Where anything occurs in the way of frost, drought, fire, insect defoliation, or any other check on growth, it is recorded in the wood. In northern countries, where this check is sudden and where growth is wholly checked, a distinct ring, called the annual ring, is formed. In deciduous trees it corresponds with the periodicity of the leaf fall. In temperate regions and in the tropics, where there is a change of seasons, the annual ring is clearly marked; where the season of growth decidedly changes more than once in the course of a year, seasonal and not annual rings are produced. In cases in the north where the growth has been suddenly checked and then starts again, as would happen in case of severe drought or defoliation by insects, a so-called "false-ring" is produced. In fact, any change whatever which interferes with the activity of the tree modifies the amount and nature of wood production. The whole life history of a tree is accurately recorded in the rings of its trunk. Within the ring itself there

is often differentiation. This is usually in the form of spring and summer wood—spring wood on the inner side and summer wood on the outer edge. This is very distinct in our Southern pines. In many instances growth is so slow that the annual ring is hardly visible, while in other cases it may be an inch or more in width. The annual production of a ring or layer of wood is so uniform throughout the great wood-producing regions of the globe that foresters base their calculations upon it. The volume of wood which is added to the trunk each year is called the annual increment of the tree. The sum of the annual increments of all the trees on an acre gives the annual acre increment. This is difficult to calculate on an acre of very irregular mixed woods. At the same time a knowledge of the rate of growth is a very helpful guide, so that one may not inadvertently cut the wood faster than it really grows. The average annual increment is the amount which one may cut each year without injury to the forest. The increment is the interest; the growing stock, the capital. As the forest becomes more and more uniform in nature, and as the conditions of growth are improved, the increment, or yield, increases until the forest approaches a normal state, and the yield or increment equals or approaches the possibility of the forest. Thereafter calculations are more uniform,

and yields more certain and even in quantity. There is a qualitative as well as quantitative increment. Of the two, qualitative increment is often the more important, because good wood sometimes sells at a rate out of all proportion to its bulk. We should strive to produce, therefore, not only a large quantity of wood, but the largest possible quantity of the choicest grade of wood. This can be done only by the closest attention to the rules of silviculture; but, as has been already stated in a previous chapter, practical limitations often hinder the merest approximation to our cherished ideals.

The function of the woody trunk of a tree is mainly support. It forms an axis which supports the branches and branchlets, which, in turn, hold the working parts in the best positions in reference to light. In the open, it is irregular in form, short in stature, and often fortified by heavy buttresses. It is thus able to withstand heavy gales. In the forest, it is often a slender column bearing at its top a bouquet of foliage. It has no individuality. If left alone, without the support of its neighbors, it bends over, helpless, of its own weight.

The trunks vary, of course, in size and form with every species, from the stunted Alpine spruce to the big trees of California and the karri (*Eucalyptus diversicolor*) of Australia.

Trees reach maturity and gradually die as do animals. Some may live five thousand or more years, others only a few years. As a tree grows older and

A Fallen Live Oak covered with Moss.

larger, its points of attack grow larger in number. It offers each year a greater surface to the gales, and to other destructive agencies. Unlike animals, how-

ever, most trees may be perpetuated asexually by means of cuttings for a long period of time. A banyan may live on for centuries. The original trunk may die and disappear, but other trunks will take its place. In fact, constant wind blowing in one direction may, in the course of centuries, cause a banyan-tree to move some distance from the place where the tree first started. There are chestnuts on the slopes of Mt. Ætna which bore fruit when Homer was a boy, and in Southern Mexico there is an old cypress which was probably twenty centuries old when Columbus landed. Although a tree may live for ages, there is, from a forestry standpoint, a maturity to the forest. Careful measurements show that after a certain period in each species the average annual increment begins to decrease. When the amount of wood addition has reached its maximum the tree has reached its volume maturity. When the amount of wood which is added each year is no longer sufficient to pay interest on the capital invested, the tree has reached financial maturity. In the one instance every inch added to the diameter of a large tree, within certain limits of course, adds much to its value, because old large wood is usually most desirable, while at the same time the interest is now accumulating at a fierce rate on the amount invested. I said above, "within certain limits," because the big trees of Cali-

fornia are really undesirable for lumber, because of their size and the great difficulty and expense attending their exploitation. A tree is usually cut when it reaches merchantable size. Merchantable size depends upon the kind of wood, and the purpose for which it is intended. The time element and the danger to the capital involved worry the private owner to such extent that the tree is usually cut just as soon as it can be profitably utilized.

CHAPTER IV

THE FOREST AS AN AGENT IN MODIFYING THE SURFACE OF THE EARTH AND IN CHECKING THE DESTRUCTIVE FORCES OF NATURE

"I regard the forest as a heritage given to us by nature, not for spoil or to devastate, but to be wisely used, reverently honored, and carefully maintained."—*Baron Ferdinand von Mueller.*

1. The Forest as a Soil-Former

Vast areas of fertile land consist almost exclusively of the detritus of the forest. Vegetable matter, in the form of humus, resulting from the decomposition of the litter on the forest-floor, has formed in many places several feet in thickness. The acreage of swamp-lands which have been formed in this way is immense. In addition to large patches of swamps here and there, there are many miles of swamp- or river-forest along our Southern rivers. The process of soil formation by the annual addition of vegetable matter may be seen to good advantage in the Dismal and Okeefeenokee swamps of our South. By digging through the vegetable accumulation of the Dismal Swamp for several feet, one

reaches sand containing shells. This indicates that the depression in which the swamp was formed was once an arm of the sea. It began, no doubt, as a salt-marsh; later a few trees, which could endure such conditions, found a foothold, and now it is covered by a dense forest-growth of many species. Little by little the forest detritus has increased in thickness, until the swamp has reached an elevation higher than the surrounding land. In fact, elevated swamps are common in many parts of this country. A swamp is usually defined as a tract of land, with or without trees, lower than the surrounding country, and so saturated with water as to be unfit for cultivation. The term "swamp" in the South usually refers to a wooded region which is often higher than the surrounding land, and, when cleared and drained, forms excellent farm-land.

The bald-cypress (*Taxodium distichum*) is a wonderful tree in its ability to grow in water and mud. It is not preference on the part of the tree, however; it is endurance. It grows just as well, if not better, on the upland, but is able to endure these conditions better than other trees. All roots must have air, and this is provided in the case of the cypress by knees which extend upward above the surface of the water. In addition to forming soil by the fall of leaves and twigs, the roots collect sediment and flotage, and

thus hold the soil in place against the action of the waves and currents.

A remarkable land-former is the mangrove-tree (*Rhizophora mangle*), which grows in great abundance along the shores of tropical seas. The seeds of this tree germinate while still attached to the parent plant, and instead of the seed, a young plant falls to the water, and is washed hither and thither by the waves and currents until it finds a foothold on some coral reef. There it grows and spreads, and soon forms a swamp in which vegetable matter quickly accumulates. Vast areas of shallow water between the Cuban mainland and the Isle of Pines are being rapidly converted into swamp by the action of the mangrove. The Bahama Islands and Florida keys consist of hundreds of small islands and reefs which are fringed with tangled masses of mangrove. After the little plants become thoroughly fixed, the birds and currents bring seeds of other trees from distant shores. As with the cypress, the mangrove projects roots into the air for the purpose of securing oxygen. Thousands of square miles have been wrested from the sea by the marvelous activities of this tree.

Soon after large quantities of organic matter have been collected in the meshes of the mangrove's roots, the coconut-palm, the fruits of which are carried long distances by ocean currents, finds a conge-

nial home. Southern oceans are dotted with little islands, fringed with green mangrove swamps, high

A Swamp Forest along the Ocklawaha River in Florida.

above which tower the coconut-palms. The establishment of the coconut means the possibility of human habitation. So many and varied are the products of the coconut-tree that, with the fruits of the sea, sufficient food material is afforded for the subsist-

ence of mankind. Besides yielding food and materials for house construction, just in those places where fresh-water is the poorest and scarcest, the green nuts yield a cool, refreshing, and nutritious beverage.

A Mangrove Swamp on the Coast of Florida.

The process of land and soil formation through the aid of trees and forests is by no means confined to southern countries and southern forests. The willow, that Cinderella of trees, clothes with abundant green, low marshy places in northern districts, and in addition to holding the soil, yields pliant twigs which

are extensively used in the manufacture of baskets and other wickerwork.

Even in the cold bogs of the North, the arbor-vitæ is constantly aiding in the formation of soil. Many other trees and bushes are performing the same function in almost all parts of the world. Examine carefully a still pond in the woods, around the edges of which there is tree-growth. The bottom of the pond will be covered with a thick coating of leaves which have fallen into the water from the overhanging branches.

Besides mechanically forcing their way through the crevices of rocks, the roots of trees secrete acid, and this, combined with the acids produced by the decomposition of organic matter, causes the disintegration of rocks. In limestone regions the roots of trees dissolve their way through rock, and thus aid in the formation of soil. This may be seen to good advantage in coral districts, where the soil is thin, but where vegetation grows luxuriantly in the solid rock.

2. The Forest as a Soil-Improver

The richness of a virgin soil is proverbial. In many parts of the world which have long been cultivated, the soil has lost its virginity. By virginity is meant freshness and richness due to an abundance of plant-food, and of humus or leaf-mold. Humus, in

decomposing, furnishes materials upon which plants feed. A virgin forest-floor is full of nourishing plant-food. Humus forms a mulch or blanket over the surface which holds the soil and prevents leaching and washing.

The nature of humus varies in different parts of the world. Its formation is dependent upon warmth and moisture, and is aided by various fungi which live in it, and by animals, such as earthworms, which ventilate and work it. In northern regions vegetable matter accumulates in the form of peat, and fails to decompose as rapidly as it forms because of the cold and absence of soil-fauna. In temperate regions it disintegrates much more rapidly, and in tropical districts, in the presence of sufficient moisture, the process of humification is very rapid. In the forests of the northeastern United States the litter on the surface is called "duff."

While the accumulation of such material protects the surface of the soil and holds moisture, trees will grow with more rapidity in regions such as exist in the tropics, where the humus disintegrates quickly, and constantly supplies the root system of the forest with a great abundance of the proper kind of food material. In dry and windy countries, and in woods where there is insufficient shade, the formation of humus is hindered. The litter is dried by the sun and

wind, and fails, therefore, to form a mulch over the surface of the soil.

In addition to serving as a protective blanket, this humus, in disintegrating, constantly furnishes mineral food materials for the roots. A large part of this material has fallen upon the surface of the forest-floor in the form of leaves. Thus ingredients which wash into the deeper layers of the soil are brought again to the surface through the action of the forest. The best way to revive worn-out land is through the agency of forest-growth. The peasants of the Old World know well the manurial value of forest litter. Although the foresters protest against its removal, these peasants cling tenaciously to their old-time rights in this respect. Even in tropical countries where the land is very fertile, plantations are often abandoned, and fresh land cleared. Rob a soil of the humus it contains, and you rob it of its life and vigor.

In the primeval woods trees mature and, after standing many years, fall to the ground and rot. Such woods are, in consequence, very irregular in nature, with gaps here and there, and with semi-decayed logs piled in every fashion, just as they happened to fall. In a well-cared-for forest, the trees are cut at maturity and removed, and thinnings and cleanings are conducted so that the conditions of the forest-floor and

canopy may be most conducive to soil betterment and rapid growth.

The sandiest soil, the barest rock, and even shallow lagoons, if situated in a congenial climate, and not interfered with by mankind or other preventive agencies, will in time become fit for forest-growth. In the case of shallow lagoons, the work begins with aquatic plants of many sorts, which gradually cause the formation of soil. The water-hyacinth in many parts of the world, especially in Florida, has so clogged even the rivers that navigation has been seriously impeded. Swamps on the edges of shallow lakes and ponds are fringed by a zone of pioneer aquatic plants. On sandy soils and rocks the low lichens, mosses, and herbs first play their part; then bushes and shrubs; then the less exacting of trees, such as the pines; and finally, when the soil has reached sufficient depth and fertility, the climax forest, consisting of rich hardwoods, such as oaks and beeches, with a few conifers, such as hemlock, is in time produced. By the excessive removal of forest litter and the reckless destruction of the forest by fire, the process is reversed. The work of centuries is quickly undone, and the soil is left in the form of sterile, shifting sand, or barren rock. Forests should be grown on poor soil, because it will be constantly improved under their influence. When agricultural

land becomes worn out, it should be planted again in forest, and fresh land cleared. In this way, by a process of rotation similar to the rotation of crops in agriculture, the productivity of the soil may be constantly increased. The forest will return to the surface the inorganic materials which have eked away in the process of cultivation. In forestry, "rotation" usually means the length of time from the planting of the forest until it is cut. In agriculture, the term rotation implies alternation; that is, for example, corn one year, oats the following spring, then wheat with grass and then corn again.

The fertility of a soil depends very largely upon its ability to hold moisture, and upon the presence of sufficient oxygen in the soil. The interstices or spaces between its granules must not be too large nor too small. When the interstices are too small the soil becomes hard, and the movement of water is impeded. This condition is ameliorated by the presence of organic matter, and by the holes which are formed by decaying roots. When the soil is too coarse and open, humus serves to fill up the interstices. The organic matter in the soil acts as a wick, which, by capillarity, carries water downward when it exists in abundance on the surface, and upward when it exists in great abundance below. By the action of organic matter the particles of soil are

corroded and comminuted, that is, diminished in size—a process which does not injure fine soils containing an abundance of humus, because by its presence the proper degree of capillarity is assured, but which decidedly improves coarse soils by removing their greatest drawback, which is excessive porosity. In short, the presence of the proper kind of humus is a great benefaction to all grades of soils. The greatest source of the best kind of humus is the hardwood forest.

3. The Forest as a Soil-Fixer

One of the most important functions of the forest is the fixation of soil. The roots of the forest clasp and hold the soil in place, and the mulch and canopy of the forest protect it to such an extent that wind and water erosion are prevented. Erosion is the wearing away of rocks and soils by the action of both water and wind.

In many parts of the world the wind blows the sand into shifting masses called dunes. In many instances, especially along the ocean, these shifting dunes have buried villages and fertile farm-lands. Dunes have been fixed or rendered stable by the planting of forests. In Gascony, in the southwestern part of France, the sands from the ocean rendered vast areas desolate and uninhabitable. To-day they are

covered with forests of pine. When the wind is light the drift of sand is unnoticeable, but during times of gale it becomes a biting sand-blast. In desert regions there is nothing to interrupt the force of the wind, and nothing to hold the soil in place. The sand is shifted here and there with every caprice of the wind, often in the form of dangerous sand-storms.

Geologists reckon that the erosive action of water has been and still is one of the most potent of all agencies in modifying the nature of the earth's surface. In mountainous districts of many parts of the world huge gorges and gulches have been cut by the rush of water, and soil and débris in huge quantities have been dumped into the valleys. By maintaining the proper kind of forest cover, the soil, even on steep slopes, will remain in place. Roots grasp and hold the particles of soil, so that the whole mountainside is knitted together. The forest is the agent by means of which mankind may harness and control these unruly forces. Not only erosion but, in several parts of the world, owing to forest destruction, great landslides have occurred, which have buried villages. Rocks, earth, and snow are held in place by a forest cover, and landslides and avalanches are thus prevented. In the Alps and Pyrenees, with the expenditure of much labor, the loose rocks are cemented to the mountain-side, and the earth is held in place by

wattlework or sticks woven between stakes to hold the soil in place until forests are started. Trees are extensively planted along railroads, especially the locust and willow, to hold embankments; and the industrious Hollanders check the force of the great rivers of the Rhine delta by planting willows along their banks. The process of washing, which carries with it the most fertile part of the field, is strikingly visible on almost every hillside farm. Every stream in cultivated regions is more or less discolored with mud which has washed from the fields. This can be prevented to a very great extent by preserving the forest in the proper places, especially on hilltops and steep slopes, and along streams.

4. The Forest as a Flood-Preventer and Conservator of Moisture

In studying the causes of floods, there are many factors which must be considered. The first is, of course, the nature and amount of rainfall. The second factor is the steepness of the sides of the collecting-basin; the third, the nature of the soil; the fourth, the condition of the surface cover of the collecting-basin; and the fifth, the shape of the collecting-basin. There are still other factors, such as the number of waterfalls or dams, time of the year, etc.

At Work on a Denuded Mountain-top.

As to the influence which the forest exerts on the precipitation of moisture, there is considerable doubt. The extent of this influence is still merely a matter of opinion, and is, in short, a case of "not proven." It is safe to assume, however, that the forest mechanically increases the precipitation of moisture on high mountains and, to a less extent, in some lowlands. Where the forests are bathed by clouds and mists, large quantities of water are collected from the saturated atmosphere by the twigs, leaves, and limbs of trees and bushes. In many moist districts there is a constant drip of water from the branches, although it may not be actually raining. The larger the surface exposed, the more moisture is accumulated. The leafage, herbage, trunks, and branches of the forest offer a large surface on which it may accumulate. A forest on a high mountain, projecting into the clouds, draws from them large quantities of moisture, just as the wick of a lamp soaks up oil. The forest may have some influence on local showers, but in the case of general rainfall, its influence is so uncertain that it need not be rated in the consideration of floods. The forest is rather the result of rainfall, than rainfall the result of the forest.

The most violent floods are due to sudden heavy downpours of rain in regions with circular-shaped and steep-sided collecting-basins. In regions where the

ground is level, and the soil porous, there is, of course, little danger from floods.

In this connection we are especially concerned with the part played by the surface cover. We are also concerned with the collecting area, rather than the stream-bed, because the principal mass of water forms in the former. Here erosion also begins, imperceptible at first, but soon resulting in an immense volume of water, descending on all sides into the channel course, and collecting in its rush rocks and débris of all kinds. This powerful mass, by undermining the banks, receives constant additions, until the whole is dumped into the level plain, where the torrent emerges with diminished force. A torrent to be conquered must be attacked where its forces are scattered and easily controlled. The place to conquer it is in the hills of its source. The way to conquer it is through the agency of forest-growth.

The flow of water is retarded by roots and litter of the forest-floor. Instead of rushing quickly into large branches forming deep gulches and gorges, it seeps into the soft forest soil and appears later in the form of springs. Much of it trickles by circuitous routes into larger branches, being impeded on every hand by the forest débris. When the collecting area is covered with a dense forest-growth, the water which falls is therefore much more evenly distributed

over the surface, the rapidity of the run-off is retarded, and the destructive influences are certainly lessened.

The soil of bare regions is compacted by the beating force of the rain. The water washes quickly over the surface, quickly forms torrents, and quickly causes washouts and destruction. The forest, by its shade, prevents the sudden melting of snows. A considerable portion of the rain which falls is intercepted by the branches of the forest, and evaporates before it reaches the soil.

Vegetation uses an immense amount of water. This is absorbed by the roots and transpired by the leaves. The transpired amount varies with the species of the tree, the climate, and the condition of the soil. In many instances it is large in amount, but in winter, and at times when the atmosphere is very humid, it is slight. The amount transpired, as with the eucalyptus, is often so large that soils may be drained by planting trees.

Although it is possible for floods to occur in regions which are forested, they are uncommon, and the damage is usually slight. Although the forest is only one factor in several which must be considered in connection with the flood question, it is nevertheless an important one, as has been already proven to the satisfaction of the people in Europe, where

floods have been produced by forest destruction, and where they have been lessened by the reboisement or reforestation of the mountains.

A forest cover imparts regularity to the flow. Although the annual run-off may be the same in amount for the year from a forested or a deforested area, the flow from the forested area will be much more regular. There will be, in other words, less extremely high and less extremely low water. This is, however, to industrial establishments which may be located along and dependent upon such a stream, a matter of great importance.

The destructiveness of floods is due more to the nature of the débris which they carry with them, than to the amount of water. When they are gentle in nature, and loaded only with silt, they are often of advantage. In the case of the Nile, for instance, flood-time is a great benefaction, because it moistens and covers the soil with a layer of fine, fertile mud. The alluvial lands along our great rivers are extremely fertile, because they are formed of fine soil and humus which have been washed from the higher lands. It is not these mild, benign floods which need be feared, but the sudden gushings of mountain torrents, in the checking of which the forest exercises a very decided influence. Even freshets do good sometimes. The stream-bed is often thus cleared of

rubbish, and the water aerated to such extent that trout and other fish are benefited. This is of benefit, however, only in forested districts, where destructive erosion is prevented by the presence of trees.

The effects produced by a forest cover are evident in the least degree as to the amount of water which flows off during the year; in a higher degree as to the rapidity of the flow-off; and in the greatest degree as to the amount of earth and débris which it carries with it.

5. The Forest as a Wind-Break

All who have lived in windy countries know well the advantage of a wind-break. It affords a vast amount of comfort to man and beast. There is nothing more destructive to young succulent plants than a strong dry wind. In several of our Western States, a fine crop of grain may be ruined in a single day by a hot, dry wind. Every washerwoman knows the drying effects of a strong wind. It sucks up moisture from the soil, and beats and lashes crops in merciless fashion. Nothing is more wearisome than constant wind, and nothing is more efficient in checking it than belts of forests.

6. The Forest as a Beautifier of the Earth

It would be difficult to overrate the value of a well-kept forest as an adorner of the earth. In many places, especially in the neighborhood of great resorts, such as the White Mountains and the Adirondacks, the forest as a factor in attracting visitors is worth more in dollars and cents, many times over, than its value for lumber. The monotony of a desert or plain is wearisome. The ideal country is the one in which there is a proper mingling of well-kept forests and fields. If a hilly country, the farm-land belongs in the fertile valleys, and the forests on the hillsides. An excellent example of such a happy combination is the Black Forest of Baden, a land of beautiful forests in the mountains, with carefully cultivated fields and irrigated meadows in the valleys. The great beauty and healthfulness of this region attract many tourists and invalids. The roads are excellent and the towns frequent. Along the streams are many sawmills which are constantly working the well-earned increment into lumber. Men, women, and children find employment in the forest, on their farms, and in the various industrial establishments, many of which are dependent upon the products of the forest, or the power yielded by the forest streams. Compare this with a burnt-over, depleted woodland,

with silent sawmills and stranded population. Such a land, although capable of producing useful wood-crops forever, is worn out in appearance, unproductive, and unfit for human habitation.

7. The Forest as a Sanitary Agent

The importance of the forest as a sanitary agent is usually underrated. In affording a place where the busy brains of the world may find rest and diversion, the forest performs a beneficial service to mankind. It performs also a very important sanitary function in affording clear, pure water to large cities. Water, to be good in quality and regular in quantity, should come from an uninhabited forested watershed. Upon the purity of such water depends the healthfulness of the millions of people who live in cities.

Stagnant water and organisms of disease are rare in the forest. In the Dismal Swamp of Virginia, for instance, the water is healthful, while in the surrounding burnt-over pine land, with here and there stagnant pools of water, malaria is common. Malarial diseases follow in the wake of forest destruction. Clearing new land in many places causes malaria. It is the experience of travelers in tropical countries that fever is generally worse in the open districts. It is not in the forest but in the land inhabited by infected individuals that malaria is common.

Before the planting of pine forests in the southwestern part of France, the country was very unhealthy. To-day it is a health resort. In many districts, especially near Rome, the sanitary condition has been much improved by the planting of eucalyptus trees.

Around dwellings trees prevent the spread of disease by arresting the dust. On the particles of dust the germs of disease are carried. The purity of forest air is proverbial.

The following is from a paper by Mr. D. E. Hutchins, Conservator of Forests, Cape Town:

"The prudent foreigner, looking across his wooded mountains, will tell you that England is rich, and can well afford to pay in the future for her present forest improvidence. There is more than this in the forest question, and, to my mind, it is quite the saddest aspect of it.

"Great Britain now pays about £20,750,000 annually for imported wood and forest produce, that could be produced equally well in the British Isles. Broadly speaking, this wood is paid for by manufactured goods produced by the labor of the factory operative, that physically degraded type of humanity one sees in all big manufacturing towns. With the destruction of the forests in England have gone the stalwart men who once worked in them, to be re-

placed by the factory-hand—weak-lunged, knock-kneed, and sallow. One has only to travel through the forests of the continent of Europe, and then visit a few of the large manufacturing towns of England,

A Road through a German Forest.

to have this physical degeneration of the race brought home in the most forcible and unpleasant manner. The wood industries are mostly healthy (to a great extent out-of-doors) occupations, and they usually employ a robust country population, living partly on the forest and partly on their gardens and small agricultural allotments. But let us consider the one million people that in Germany live and labor in the forests. What a reserve of national strength! They

are fairly, most people would say sufficiently, educated; and their healthy life in the open air and constant exercise preserve a physical development, a strength of frame and constitution, that is rare in these days of machinery and easy chairs! Judging from what I saw at a recent visit to the forests of Germany and the big towns of England, I should say that England could better afford to pay £20,750,000 for foreign wood than to lose the broad-shouldered and muscular men who once worked in her forests. These are the men whom we value as colonists—men fitted to go forth and subdue the waste places of the earth."

CHAPTER V

THE GEOGRAPHICAL DISTRIBUTION OF FORESTS

Even the most casual observer, in traveling from place to place, notes with interest the various phases of forest vegetation. In every region, except where the conditions are so inhospitable that nothing can grow, various plants are grouped together in the form of communities or societies. The species which constitute these communities have in common the ability to endure the peculiar conditions in which they live. Every species fills a niche which it holds against intruders, in consequence of some peculiar advantage or ability which it possesses. These groupings are the result of various warring forces. In some places there are deserts which are practically devoid of vegetable life; in others, prairies and savannas, with a few herbaceous plants, especially grasses; in others, swamp-lands, and all gradations of forest-growth, to the most luxuriant form of vegetation, which is the tropical forest. This enjoys constant warmth, constant moisture, and suitable soil conditions. Although plants have, in the course of time,

become adapted to all sorts of conditions, the ideal condition in which most plants reach their optimum is in a climate in which there is never frost, in which there is always sufficient warmth and moisture, and in which the soil is of the proper quality both chemically and physically. In such an environment the struggle for existence is not against the parsimony of Nature, but between the individuals which constitute the community.

Every clime is capable of supporting a certain number of living things in proportion to its natural resources. These ultimate resources are sunlight, warmth, moisture, and suitable soil. In the presence of the proper proportion of these conditions, vegetation reaches its maximal growth. The vegetal, and especially arboreal population of such a region is usually extremely high, so high, in fact, that the struggle between the members of the community is most intense. Every individual must fight incessantly in order to hold sufficient space in which to grow. These ultimate resources do not exist throughout the whole world in the proper proportions. Whenever there is proportionately too little or too much of any one of these resources, then there begins a struggle with the environment, and only those species survive which are able to endure the abnormal condition. Therefore, we have, distributed over the face of the

globe communities of plants which can endure varying degrees of cold, an excess or scarcity of moisture, or unfavorable soil conditions. The population of plants and animals is greatest in those regions where vegetation reaches its optimum, and decreases as one moves into regions where Nature's ultimate resources become more and more meager or out of proportion.

The simple fact, however, that a certain species may be found growing only in a very limited range is no reason for believing that it will not grow elsewhere. Many species which have been moved from their native place have met with new enemies and have perished; others, however, in being moved have escaped their foes, just as the American locust escapes the borer in Europe. The forester is especially concerned with the possible range of all the species of important forest trees. The range of one species overlaps another depending upon its endurance or adaptability. In the zone in which the overlapping occurs, there is a change of neighborly relations of the species, and a varied rivalry in consequence. The red-cedar, for instance, beginning with Cuba and ending with Canada, passes through the natural ranges of many species. Because of its wonderful adaptability or versatility, it is a member of many communities. In the South it is a hydrophyte, or swamp-plant; in other places, it is a xerophyte, or drought-

plant, and in other places it endures other adverse conditions of many kinds. Although its distribution is more or less dependent upon birds which scatter its seeds, it is due mainly to the wonderful ability of the species to adapt itself to a great variety of conditions. The rate of growth and the quality of wood vary accordingly. It is, however, in the moist, warm, fertile districts of the Mississippi bottom-land, and in Florida, where it reaches its optimum. The bald-cypress is classed as a true hydrophyte, or water-plant. Although it does not endure much cold, it is a beautiful shade tree in the neighborhood of Philadelphia, on the upland. Its northernmost natural range is along the Pocomoke River in Maryland. It has endured considerable drought on our southern prairies in Texas. Although it endures these diversities of environment, it grows best in rich, warm, moist, but well-drained sandy soil. The simple fact that a tree grows naturally in the greatest abundance in certain localities is no indication that it will not grow as well, if not better, elsewhere.

The day is past when we should concern ourselves exclusively with the species of our own country, in spite of their abundance and great variety. We should search the world for those species of the greatest value, which will grow to the best advantage in various parts of this country. In this way every

country may be developed to the highest pitch of productiveness, with the least waste of energy and time. Conservatism in such matters is a loss to ourselves and to posterity.

Natural distribution of species, as it stands to-day, is mainly a matter of accident. The locust, red-oak, and Douglas-fir are as well, if not better known in Europe than in their native land. It is said by the foresters in Hungary that "the locust has been discovered in America especially for the Hungarian plain." The eucalyptus of Australia is at home in California, the ailanthus and paulownia come to us from the Orient, and a visit to many arboreta in tropical as well as temperate regions should convince us that experimentation with exotics is in its merest infancy.

In order to understand the peculiar groupings of plants in societies over the face of the earth, we must consider the various agencies of, and drawbacks to, the extension of vegetation. There is a tendency toward a settled equilibrium, but just as long as the forces of extension and interruption are inconstant and sporadic, just so long will the ranges of the various species change. The idea of a natural range of an economic plant no longer means much, and is no longer of much importance, except as a matter of history. Few people are concerned with the natural range of the locust-tree. Its possible range is of much

more importance. We should be much more interested in knowing where trees will grow, than where they have grown.

1. Aids to Forest Extension

Seeds are often provided with attachments to aid in their dissemination. Some seeds have wings by means of which they are blown long distances by the wind, such as those of the spruce and pine, which whirl in a circle as they fall to the ground. In that way their fall is retarded, so that the chances of their dissemination by the wind are greatly increased. The seeds of the basswood, or linden, are borne on the midrib of the leaf, which falls with the seeds, and acts as a kite in aiding their distribution. Some seeds are formed within little bladders, as with the hop-hornbeam. The bulk is large in proportion to its weight, so that transportation by the wind is facilitated.

Birches and poplars often appear on burnt-over land far away from the mother-tree. This is due to the ease with which their light-winged seeds are carried long distances by the wind.

Other seeds are covered with a pulp which, when ripe, is edible. In the center there are usually one or more hard seeds which resist the action of the digestive juices and pass through the animal unin-

jured; in fact, this process often aids germination. Often this pulp is bright-colored when ripe, to attract these animals; but unattractive, in fact, extremely unpalatable, before the seeds are ripe, as with the persimmon, which is extensively distributed by the opossum. Birds are the most active animal seed-disseminators. They fly over mountains and seas, and in their migrations scatter here and there the seeds of the plants upon which they feed.

The rich, oily meat which Nature has stored in nuts to feed the young plantlet until it develops leaves and roots, and can care for itself, is a much-coveted morsel, for which a squirrel is willing to work long and hard. Many seeds are overlooked by the squirrel, or are buried and forgotten. Animals of this kind often store away for the winter more provender than they can consume, and of these some may sprout and grow. The dissemination of these heavy-seeded species is therefore slow.

Many fruits are so constructed that they will float long distances. The coconut is an interesting adaptation in this respect. It grows close to the ocean, and would crack in falling to the strand were it not covered with a husk, called coir. When the nut falls, it often bounds into the sea and floats many miles with the currents.

The common Brazil-nut is an interesting fruit.

About twenty of these nuts are formed together inside an extremely hard round shell. It resembles a small cannon-ball. This fruit falls with such force from the high trees that the natives protect their heads and shoulders with bucklers of wood. If the ground is soft, it buries itself in the soil when it falls. It is so full of oil, however, that it floats, and is probably carried from place to place in times of flood.

Some fruits are so constructed that they explode and shoot their seeds some distance, as with the sand-box-tree of the tropics. It is often called the monkey's dinner-bell; because, on hearing the explosion, the monkeys hasten to feast upon the seeds. The witch-hazel pod squeezes out its seeds just as a boy shoots a bean or apple-seed from between his thumb and forefinger. Twigs of willows are snapped off by the currents of streams and are washed ashore, where they take root and grow.

We could mention many interesting devices for the spread of plants over the face of the earth. The most potent disseminator of all, however, is man, who uses intelligence in his work of distribution. In many places he has completely changed the nature of the landscape by tree-planting, as in our Western country. Even more potent in this work than the individual, is the government, which, in hav-

ing superior opportunities and connections, can send agents to all parts of the world, experiment with the importations, and then distribute seeds with instructions. In fact, the government should control all such importations, in that there is grave danger of introducing undesirable kinds, and with them, also undesirable pests.

Long ago Great Britain sent ships to the East Indies to gather seeds for planting in her West Indian possessions. Many fine fruits and trees have resulted from these early importations.

The collection and preparation of the seeds of trees is now an important business in almost all parts of the world, and seeds of almost all valued species may be secured at fair prices from our seed-dealers.

Many other causes have stimulated the spread of seeds. The introduction of the honey-bee into America has, no doubt, increased the amount of seeds produced by the locust, basswood, and other trees, and of course the larger the amount of seeds produced, the greater the number of young trees and the more rapid their extension.

When a person drops a seed into the ground, it is impossible to predict the result. He often accomplishes more than the addition of a single tree. He plants a seed-producer which yields other seed-pro-

ducers which would cover the earth but for certain hindrances or barriers which prevent their spread.

2. Barriers to Forest Extension

The spread of seeds is often hindered by high mountains and seas. In many instances plants have been thus confined or imprisoned in small areas. The greatest of all barriers to tree-growth is cold. It is this which determines the northern limit of all trees, and the timber-line on mountain sides. Below about 43° Fahr., vegetative activity is not possible. The temperature for at least six weeks of the year must exceed that figure. Many claim that the plants of temperate regions need the rest of winter. If so, the arctic willow has mostly rest, and is in consequence only a stunted tree form. Although northern species have, in the course of time, become adapted to this condition of affairs, long inactivity can be of no advantage whatever to any plant or animal. In many cases in our north it is a case of mere existence, and not growth. Conifers cover vast areas of our north mainly because they are able to work at a lower temperature than deciduous trees. They are, on the whole, less frost-tender, although there are pines, such as the famous stone-pine of Italy and the Cuban pine, which are very sensitive to cold. When pines or spruce are frozen throughout, as is

A Rocky Region above Timber-Line in the Alps.

often the case, there is of course no activity; but in warmer times, in the spring and fall, while broad-leaved species have no leaves, they are of course more or less active. At any rate, the cessation of growth in winter, as with drought in summer, is an enforced idleness which can serve no purpose, and is therefore not rest. The amount of wood which is added in so short a time is therefore small in quantity.

In the tropics there is continuous growth in regions where there is a commensurate amount of moisture. In many instances the leaves fall, the flowers and fruit suddenly appear, and then in a short time follows again a new crop of leaves. In many instances, if not in the majority of cases, in warm, moist regions, there is no periodicity of leaf-fall. The trees are there evergreens, and growth is constant. The peach is an evergreen in Ceylon.

Many northern species suddenly transported southward would die, no doubt, in short order. Northern trees have become more or less adapted to the conditions of the environment in which they live. Their mechanism is not fitted for a sudden change, although a northern tree moved south is more likely to thrive than a southern species moved north. It would be dazzled by the excessive sunlight, and its tender leaves would be shattered by tropical hurricanes and downpours. It might be stifled by its more

vigorous neighbors, or fall an easy prey to insect and fungus pests, which would relish a new food material; but by a slow process of acclimatization and fostering care, however, even our northernmost species might in time become accustomed to the new environment. Northern annuals would become perennial, northern light-demanders would become shade-demanders, and northern slow-growers might become rapid-growers under the favorable conditions of a southern climate.

In the tropics there are many palms which have no representatives in northern regions. The commonest grasses, such as bamboo, grow to be trees. The same is true of ferns.

Slow-growing and rapid-growing are only comparative terms. There are slow-growers and fast-growers in the tropics as in northern regions. There are many heavy slow-growing hardwoods in the tropics, but, as a rule, in consequence of the abundance of warmth, moisture, and fertile soil, growth is very rapid. Although the highest mean temperature for the year is found in the torrid zone, the maximum readings of the thermometer are obtained at about the thirtieth parallel of latitude during the summer. It is also in about that region, which is in the neighborhood of New Orleans and St. Augustine, that frost often causes very serious damage. It is about here,

also, that many of the trees of the Eastern United States reach their southern limit.

The great cold wave which covered a large part of this continent during the glacial epoch must have exercised a gigantic influence on the northern distribution of many species of trees. It could not have driven them southward, because trees, unlike animals, can not be easily driven. Tropical life once existed in arctic and temperate regions. Although the seeds of many trees will retain their potency a long time when embedded solidly in ice, it is safe to assume that none survived in those regions which were actually covered with the grinding ice-mass of the glacial epoch. Its chilling effects must have been felt far southward. Since that time, no doubt, species have been moving slowly northward, depending mainly upon the various natural agencies of dissemination, especially the wind. The species with heavy seeds, such as oaks, walnuts, and hickories, have lingered behind. These changes will continue, no doubt, until every species finds the northernmost limit of its possible range. Those species with the lightest seeds are not always those of the broadest range. This depends upon the ability of the tree to endure adverse conditions. The giant Sequoia, of California, is limited in its range, although its seeds are very small and light, and widely scattered by the wind. The

aspen, on the other hand, with its light seeds and ability to grow almost anywhere, extends from Labrador, Hudson Bay, and the Yukon River in Alaska, southward to Mexico, and from the Atlantic to the Pacific.

The second most important factor in determining the distribution of species is moisture. Without some moisture no tree can live. The conifers, in temperate regions, use per year, according to some authorities, as much, if not more, water than broad-leaved species. While the broad-leaved species are in leaf, however, they use much more water than do the conifers. The drier the climate and the larger the leaf surface, the greater the amount of evaporation. Therefore, plants of extremely dry regions have developed a small leaf surface, or the leaves are covered with wax or mucilage in such a way that evaporation is hindered. As a rule, the conifers, or cone-bearers, owing to their endurance, inhabit the cold zones of the earth. They grow also on the upper zone of mountains, and in dry places in the tropics. They would grow in other parts of the tropics were they not crowded out by the more vigorous and more highly developed broad-leafed species. They are truly pioneers paving the way for the broad-leafed kinds which are constantly creeping in, and because of their vigorous coppice-growth are holding their own. In

northern regions, such as the Adirondacks, coppice-growth is slight. In many parts of this country the pines have been replaced by the broad-leafed species.

THE DESERT OF UTAH.
Showing lack of vegetation and wind erosion.

In the total absence of moisture a desert results. Some species, after long years of hardship, have become inured to a scarcity of moisture, especially the cacti, the leaves of which are thorns and the stems of which have developed into leaf-like structures. These stems are storehouses of moisture, and the thorns are a protection against the greedy animals of the desert. The date is a very valuable tree, which is able to with-

stand the rigors of desert life. What the coconut is to the shores of tropical seas, the date is to the desert.

The next great barrier to tree-growth is unsuitable soil. Often there is insufficient soil; often the soil contains alkali or salt, and very often there is hard-pan near the surface which prevents the penetration of roots. It is very seldom that tree-growth is prevented by a lack of nourishing food material in

A Scene on our Western Prairies.

the soil. Although trees are often in a half-starved condition, it is an extremely poor soil which will not support tree-growth of some kind. The formation of grass- or savanna-land is often due to hard-pan, which is hardened or indurated soil. Hard-pan not

only prevents the penetration of roots, but, because of imperfect drainage, the ground is sour and stagnant in nature, and therefore not conducive to tree-growth.

Although the winds occasion the spread of seeds, they also hinder tree-growth, if constant and severe. Although winds are checked by belts of trees, large areas of forest are often leveled to the ground by the action of gales.

Fire has been for many years, even before the advent of mankind, and is still, a very potent agent in molding the nature of the surface of the earth. Lightning and volcanic fire have often set it. The lowlands have suffered less than the highlands, because of their moistness. Glades with open pasture, with here and there a tree, are, no doubt, due in many cases to fire. Fire on a heavy soil tends toward the formation of grass-lands. The weaker species of the forest suffer first, then after a succession of fires only the hardiest remain. In the course of time even the hardiest forms are killed, and a prairie or desert results. Where fires have been stopped, the forest is invading the prairie-land. It is said that in the dry parts of Australia there are species of trees with seeds which will not germinate until their outer husk is cracked by fire. The following is from the Agricultural Gazette of New South Wales:

"It is a curious thing to those who do not know the nature of the seeds of some of the tribe or natural order Leguminosæ—the Albizzia, alias Mimosa, alias Acacia, alias Prickly Wattle, Hickory, Myall, Mulga, Black Wattle, etc., etc., and which tribe constitute our scrubs—that burning-off causes them to grow after lying in the ground for years; after burning off the stubble of what has been used for a long time as a cultivation paddock, wattle scrub will spring up which is almost impenetrable, and that after the memory of a tree in the district has been lost. It seems to require a fire to crack the outer case that moisture may penetrate and cause germination. This is why constant clearing is necessary; in other words, selectors burn off thinking to destroy, but they really assist and force the growth of these scrubs. Grass-burning will cause a sweet grass to grow, it is true, but with it acacias of various kinds spring up, some on the first year and more on the next, for they do not all get roasted alike, and the unknowing wonder where the growth comes from. The land at some previous year had wattles, etc., but, as they only live seven years, had died off; and no previous fire, no growth. In this peculiarity the wattle tribe does not stand alone: it is so with many other plants known to botanists." Our Western lodgepole-pine is of interest in this respect. The seeds are formed in an extremely

tough cone. The fire may kill the tree, but the seeds are often uninjured. This pine is thus reproduced in spite of fire. It is this peculiarity which, in part at least, accounts for its wide distribution over areas subject to frequent fires.

The Indian set fire to improve the berry-crop, a common practise still in many parts of this country. He desired open places and pasture to furnish food for game and to facilitate hunting. Fires are commonly set to-day in the forest throughout our South to improve the pasturage.

Constant burning has tended to reduce the number of species, and produce many open pure woods. Some trees are, however, gregarious. This flocking together is probably due, in part at least, to the fact that some species produce much more seed than others, and that this seed is produced in immense quantities, not every year, but every now and then, in what are called seed-years. These seed-years occur with more or less regularity, and the seeds sprout and mature together. In this way one species may often gain complete possession of the soil.

Browsing animals, such as cattle and sheep, are, of course, more or less destructive to forests. Young trees of good flavor are soon devoured, while others are injured by trampling. A camel will eat a canvas tent, a giraffe can reach with its long neck the most

tender foliage of the tree, and an elephant with his powerful proboscis can uproot trees of considerable size with little difficulty. The moose not only eats the branches and bark of young trees, but by jumping on saplings bends them over and holds them down while he eats their tender tops. The word moose, it is said, comes from the Indian word "musu," which means "wood-eater."

Plants are usually protected against animals by poisons, disagreeable flavors, or spines. The holly possesses prickly leaves, and the liquidambar is usually left untouched because of its pungent flavor. Cattle eat the leaves of the mulberry with avidity. In Italy and many other countries, cattle and horses are fed upon leaves. Sheep are often used for the purpose of clearing land. They devour both the weeds and the young trees. When we consider the hordes of bison which wandered over our plains, to say nothing of the lack of moisture, compact soil, and periodic fires, there is little wonder that they are treeless.

Disease due to insects may kill certain species and leave others untouched. Injurious insects have suddenly appeared, caused an immense amount of damage, and then suddenly disappeared. Several of our most beautiful and valuable tree species have been many times in jeopardy because of insect pests.

The only insect defoliator or leaf-eater which has

been of benefit to mankind is the silkworm, which feeds upon the leaves of the mulberry. When the vitality of the forest has been reduced by fire it falls an easy prey to the ravages of insects and other disease-causing organisms. Injurious insects are usually kept in check by their enemies. These enemies are other insects, birds, toads, and other animals.

Weeds are often a hindrance to forest-growth. In many instances, grass, climbing vines, and dense thickets of bushes, have complete possession of the soil, so that young growth is seriously hindered, especially in the south. In the north this kind of growth on the ground is often a benefit, in that it may protect young trees against the action of frost.

Then, too, between the species of the forest and between the individuals of the species there is constant war. In tropical countries where the struggle is most intense, there are mortal hand-to-hand combats.

Perhaps the greatest barrier to tree-growth is man. In addition to causing fires, he uses those species best suited to his needs, and leaves the most undesirable kinds, and thus often causes forest deterioration. On the other hand, in some instances, he uses skill and foresight. The forest is constantly improved in consequence. Mankind, in his process of development, has accomplished a great work in subjugating and bringing to his household many use-

ful plants and animals. The great work of the future should be directed toward the subjugation of the wilderness for perpetual forest supplies, and the reclamation of the waste lands of the earth.

All the above influences have been at work for a long period of time. They are at work at present, and we have as an inheritance all sorts of combinations in the way of plant communities or societies. These conditions vary with every district, and the products vary accordingly, and, in consequence, the industries and occupations of the people. The forester by careful cultural methods endeavors to preserve or improve the quality of the soil in such a way that the struggle of the forest with the environment is reduced to a minimum, and to control the struggle between the individuals of the forest in such a way that the largest quantity of the best material desired will be produced in the shortest length of time.

PART II

THE FORMATION AND TENDING OF FORESTS

CHAPTER VI

THE FORMATION OF FORESTS

Before beginning the formation of forests it is important to know the advantages and disadvantages of pure and mixed woods.

In the case of pure forests the management is simple. A pure forest may be regenerated with little trouble by careful selective cutting, or by cutting clean and planting afresh. In the case of a pure, irregular forest, one may cut down to a diameter limit and constantly reap a crop, provided the amount removed is never greater than the product of growth. In spite, however, of the fact that pure woods are easily managed, they are easily blown down by the wind if shallow rooted, as with the spruce. In pure woods only one kind of material is yielded, and insects may often do an immense amount of damage. With several species, or even only two species, the

danger is correspondingly less. It is rare, indeed, that an insect will injure more than one species at a time.

In the case of mixed forests it is possible to grow shallow- with deep-rooted species with safety from the action of the wind. The soil and air space are utilized to better advantage. If the underwood is of the proper kind, the soil is protected and improved. In Germany the tendency is decidedly toward the encouragement of mixed forests, although in Saxony immense areas of pure spruce are raised for pulp, and in Prussia and southwestern France one may ride through vast stretches of pure pine. The mixture of two sorts of trees is almost always advisable, especially if one is a broad-leafed species and a shade-endurer, and the other a conifer and light-demander. It is difficult to regenerate a mixed forest without planting, and greater skill is required in its management, so that in many instances pure forests are preferable. This is so with spruce, which is probably the first tree that will be extensively grown artificially in forests in our northern regions.

There will be little difficulty in securing mixed forests in this country. They are naturally too much mixed. The difficulty will be mainly in excluding undesirable species, and in maintaining the desirable species in the proper proportions and relations.

The choice of species to plant or to favor in the improvement of forests is extremely important, and should always receive much consideration. The selection of the wrong species means labor lost and disappointment after long years of waiting. It is said that a tree may thrive and give great promise in youth, and then later die and disappoint one, or *vice versa*. In general, however, it is safe to assume that if a tree does well in youth, which is, of course, its tenderest age, the chances are favorable for good aftergrowth. It is, of course, safer to plant indigenous species, or those exotics which are so well known that there can be no mistake. It is not wise, however, to cling tenaciously to those species which are native, when it is positively known that certain foreign species will serve our purposes better. The writer has known of persons who considered it unpatriotic to use foreign species. The white-pine, Douglas-fir, red-oak, locust, and tulip-tree are more extensively planted in Europe to-day than in their native country.

It is safer to plant the European spruce (*Picea excelsa*) than our native northeastern spruces. Our native spruces are difficult to distinguish from one another. Botanists are constantly disagreeing in reference to their identity. Still more difficult would it be for the seed collector to determine. Our spruces

are apparently slower growers than the European spruce. The seed of the American spruce is difficult to obtain and of course expensive. The European spruce is well known, its seed is cheap, its growth is rapid, its cones are large and seed easily collected, and it has been planted so much in this country as a shade tree that its fitness can not be doubted.

One constantly meets with surprises in forestry, and there is certainly something surprising in the fact that the Danes are planting our common white spruce on the bleak heath-lands of their windy country. The white spruce (*Picea canadensis*) is an extremely important species for Denmark, because experiments prove beyond doubt that it is excellently suited for cultivation on the poor, dry, and above all, tempestuous heaths of Jutland. Here appears to be a contradiction—the Danes choose our spruce and we choose the native European spruce. It is often, however, the case that a tree will do better in regions in which it is not native. This is so also of our common red oak and black locust, which are famous forest trees in Europe.

In the choice of species for planting or encouragement, three points at least are worth considering:

First, the adaptability of the species to the soil and climate in which you may wish to plant it.

Second, its silvicultural qualities, such as rapidity

of growth, ease of propagation, freedom from disease, etc.

Third, that it will serve the purpose for which you are growing it.

It would be risky to plant a species out of its natural climatic range, or in soil to which it is not perfectly adapted. It would be discouraging to select a species which grows slowly, which is naturally tender, which suffers from disease, and which, on the whole, is difficult to propagate. Above all, select those species which will serve your purposes in the end. This requires good judgment, because products which may be of value at present, may not be fashionable a quarter of a century in the future. Fashion often plays a very important rôle in the value of wood. Chestnut, for instance, as an interior finish, is very modern. For years this valuable wood was used almost exclusively for fence-rails and posts. The name of a wood almost condemns it. Take, for instance, the red-gum tree (*Eucalyptus rostrata*) of Australia. The name "gum" would condemn it in this country. There is no timber more highly prized than that of the red gum in its native land. Call it "mahogany," and its value would be enhanced in the minds of many people.

The value of wood may often be modified by the application of preservatives. Wood may be injected with chemicals so that decay is resisted, or com-

bustibility reduced, or stained in such a way that precious woods may be counterfeited. Instead of stains or paints, inferior woods may be covered with choice veneers. This is even practised in the manufacture of cigar-boxes. A cheap grade of poplar is covered with a fine veneer of Cuban-cedar on the outside and with paper on the inside. In similar ways even wood of inferior quality may be used. It is probably true that the sweet-scented Cuban-cedar (*Cedrela odorata*) prevents the ravages of insects in cigars.

It would be folly, of course, to plant oak for paper pulp, or poplar for ship timbers.

If the purpose of the forest is protection against the destructive forces of Nature, or for esthetic or sanitary influences, the quality of the wood is a secondary matter; but whenever it is possible those species should be selected which will serve as many purposes as possible.

After having decided upon the kind of forest and the species desired, the next step in the formation of a forest is soil reclamation, if that is necessary and possible. If the soil is extremely swampy or sandy it often pays, in fact, is often necessary, to improve the condition of the land before the kind of tree you may desire to plant will grow.

Swampy land may often be helped by merely

opening the natural ditches which drain it. In the north woods the small streams are used in winter for log-roads. They are filled with corduroy, brush, and other débris to such extent that their flow is interrupted. Many acres may be drained by a few hours' work in removing débris. When ditches are dug for the purpose of drainage they should be left open. Underdrains soon become clogged with roots and are soon, of course, utterly useless. After the trees are once well established, they will help drain the land. Trees are often planted for this purpose.

In many places where there is an excessive amount of vegetable matter, such as peat or duff, burning may be a benefit. Plants must have some mineral soil. On the coast of Alaska, for instance, this material is often many feet thick. It must be removed before a crop of anything but moss and bushes can be produced. There are vast accumulations of this sort of material in northern Europe in the form of deep peat or "torf" beds.

In the case of shifting sand it may be necessary to build brush fences or wattles to check the force of the wind and cut off the supply of sand. Brush may be piled upon the sand to hold it in place, and to protect the young plants from the sun and wind-blast. In some places it may be necessary to plant shel-

ter belts of quick-growing species to check the wind until more desirable kinds may gain a foothold, or to plant nurse trees to shelter tender species in youth from the action of frost, wind, and sun. On steep mountain sides or high embankments where the soil may slide on the slightest provocation, it is often necessary to fix it by means of wattlework before planting. This wattlework serves to hold it in place until the trees one plants have rootage enough to perform that function. Wattlework consists of sticks or twigs twisted together and woven between short stakes which have been driven a short distance into the soil. Thus a mountain side may be firmly knitted together, apparently patched and stitched like an old garment.

The exigencies of each case demand certain preliminary works upon which the success of the forest depends. When the forest is once established, no further work of this kind is necessary.

Suppose we are employed to reforest a territory in the bad lands of Mississippi or Alabama where, owing to deforestation, the clay soil has been cut by erosion into many gullies. It would be expensive and useless to fill these hollows with earth, but by building brush dams at frequent intervals across the gully, much can be accomplished. The brush dam can be held in place by stones or by poles firmly

braced from bank to bank. The water of the next rain will pass through, but the earth and débris will remain behind the brush dams until the gullies become practically filled. Then planting is easy. Along the shores of streams, bunches of brush in the form of bavins and fagots may be used to dissipate the action of the waves until willows or other trees may be used to hold the bank in place. The construction of these protective works which is preparatory to forest formation, often requires a great deal of skill and engineering ability.

For the sake of convenience more than for any other reason, the formation of forests may be divided into two categories: the first, cases in which man prepares the seed-bed and sows the seed, or plants little plants; and, second, cases in which Nature sows the seed and where man simply aids her by preparing a seed-bed under the mother trees in such a way that natural regeneration follows. One is called artificial, and the other natural regeneration. Nature does most of the work in both cases. In fact, there is little that is artificial about it in the first case. Man aids Nature a little more in one case than in the other. In one instance man sows the seed or plants the little plants, and in the other Nature does it, although in the latter man cuts in such a way that the mother trees will bear an abundance of seed, and wounds the

soil in such a way that germination will follow when the seed falls.

The seeds may be collected and then sown in a nursery where the young trees may be carefully tended, and when of sufficient size, planted on the area where they are destined to remain until the time of reaping. This is essential in the case of many tender species. In other instances direct sowing may be practised. The seeds may be sown in various ways upon the area which one may desire to stock. Only those species, however, which are not delicate may be sown in this way. In the case of small and expensive seeds, direct sowing is risky. Much depends also upon the nature of the locality. In poor soils and in regions where squirrels, mice, and other seed-eating animals are abundant, direct sowing generally results in failure. Vigorous, quick-growing seedlings, which need no protection in youth, may be successfully produced by direct sowing.

This is, of course, Nature's method, but Nature's method is characterized by the extremest kind of lavishness. Millions and billions of seeds are wasted every year. Every seed is a ball of extremely rich concentrated material, which has consumed a large part of the tree's energy in its process of manufacture. Were there no forest fires, no lumberman, no injurious insects, or other destructive agencies except

old age, a tree would have to produce only one mature offspring to fill its place in order to maintain the forest regions of the world intact. Owing to the awful struggle which the individuals of the world must wage against their enemies and their own kind, every tree must produce millions of seeds and thousands of seedlings to surely leave in its place a single representative. By coming to its aid and by guiding the forces of Nature over which the tree has no control, man may rescue from extinction many valuable individuals and even species. He can control the production of wood, just as he controls the production of wheat or of corn.

In the formation of forests nothing is of more importance than the quality of the seed. Seed should be ripe, fresh, and of standard weight and size, and all seeds should be tested before sowing. In a single pound of birch seed there are 800,000 seeds, while the fruit of the double coconut, which contains four seeds, weighs from forty to fifty pounds.

It is usually conceded that the dominant trees of the forest are produced by the largest and richest seeds. The best seed produces the best trees and the best seed-producers. In the struggle for existence a small advantage in the beginning may mean life and vigor to one tree, and suppression and death to many others.

Let us, for the sake of experiment, collect some white-pine seed and sow it in a little bed. A few will germinate the first year, a large number the second, a few the third, and some, never. In the same bed at the end of three years we would have one-year-old, two-year-old, and three-year-old plants. It is easy to see that those which germinated the first year would have a great and lasting advantage over those which sprouted later. This, however, is probably economy on the part of the tree. Seed years are not frequent in northern districts. Those which sprouted the first year may meet with difficulties and perish. There is then still a chance that some of those which sprout the second year, and even those which sprout the third year may survive. By soaking the seed in water at a temperature of 130° for twenty-four hours, the majority that will sprout at all will sprout at once.

Great care must be exercised in the sowing of soaked seeds. If sown in dry soil they will perish. By scalding locust seed, or by soaking it in warm water for three days, the outer hard encasement is broken, and the seeds will soon sprout, but if these are sown in dry soil, all may be lost.

The germinating power is greatest soon after the seeds are ripe. In many instances, especially in tropical countries, seeds germinate just as soon as

they fall to the ground, and even in a few cases while still attached to the parent tree, so that, in fact, the seedling and not the seed falls.

The seeds of *Castilloa elastica*, the Central American rubber tree, can be kept only a few days. Packing seeds in charcoal, in air-tight boxes, may prolong their life, but in some instances, in spite of great care, the period of vitality is extremely short. Some seeds retain their vitality for several years. The statement that wheat seed, three thousand years old, from Egyptian mummy cases, germinates, is, however, one of those lies which live on in spite of their preposterousness.

When seeds are stored, they must be kept in a cool, airy place, which is neither too dry nor too damp. The outer encasements and hard shells of seeds perform the same functions that do the scales of buds. They protect the seed from the absorption and the evaporation of too much water. In fact, a seed is not unlike a bud. Both contain an embryonic individual which is capable of developing into a mature organism, retaining throughout the characters of the parent which produced it. One, however, is sexually, and the other asexually produced. One is the result of the union of the male and female elements of two individuals, while the bud is merely a growing point surrounded by nascent leaves and pro-

tective scales, and which, on being segregated, is capable of producing a plant similar to the single parent. Seeds and buds are both reproductive units. In addition to the scales which both possess for the prevention of excessive imbibition and evaporation, seeds are often supplied with extremely thick, hard encasements.

It appears in the case of the black walnut, for instance, that the shell has developed in the course of ages as a protection against gnawing animals. This is doubtful, because the teeth of the animal would grow longer and sharper as the shell of the nut, by the process of selection, grows thicker. It is questionable whether, by a process of selection on the part of the squirrel, the thickest-shelled specimens are left. It is not possible for the squirrel to determine whether the shell is thick or thin, and in fact the walnut and hickory seeds which sprout, are usually those which the squirrel has accidentally dropped or overlooked. The hard shell is probably primarily, at least, for the purpose of retaining the proper degree of moisture in the fleshy part of the nut, and not to protect it from the depredations of gnawing animals. There are many who claim that a walnut will not sprout unless cracked by frost. It is questionable whether frost cracks the shell or not; in fact, walnuts will germinate in countries where there is no frost, which, of

course, disproves the notion that frost is necessary for the germination of hard-shelled seeds.

If seeds are bunched together in piles or bins, they must be turned frequently to prevent fermentation. Chestnuts, walnuts, and similar seeds must be packed in light dirt or sand during the winter. The outer husks should be removed. In the case of black walnuts, the seed may be easily hulled in a common corn-sheller.

The source of seeds is a matter of great importance. They should come from mature, healthy, quick-growing trees. Bad as well as good qualities may be transmitted. Never select seeds from stunted trees or trees with twisted fiber. Unfortunately, it is these abnormal trees which ordinarily produce the largest amount of seed. The more adverse the conditions, up to a certain limit, of course, the stronger the effort on the part of the tree to reproduce its kind. On high mountains, where the season is so short that there is insufficient warmth for seed production, except at rare intervals, the spruce and balsam reproduce themselves by shoots from the lower branches which have become covered with moss. This is a process of natural layering. It is not uncommon to find trees which have borne an immense amount of seed and have died the following year. Some may claim that the tree died in consequence of excessive

seed production, but it is more than likely that the tree was already diseased and succumbed in the final great effort to leave behind the largest number of progeny possible.

Large sums of money have been spent for northern seeds, especially spruce, in the hope of securing a vigorous, frost-hardy variety. The wisdom of this is doubtful, for even if frost-hardiness is secured, it is bought at the expense of other desirable qualities, and slow growth, tendency to grow twisted and crooked, result. Trees moved southward often suffer from frost more than in their native land, especially in youth, because in the north Nature protects her seedlings by a thick mass of snow, and by hundreds of thousands of hardy, quick-growing birch and poplar nurse trees. The snow in the Adirondacks often falls so early that the soil never freezes throughout the winter.

The farther north and the higher the altitude, the smaller the seed and the smaller the percentage of germination, although the quantity produced is often immense.

Seeds from trees of a moist climate, sown in a moderately dry climate, do not produce thrifty plants, while it is quite the reverse of seeds which have been collected in a dry climate, and sown in one which is moist. For instance, seeds of Douglas-fir for plant-

ing in the Eastern United States are collected in Colorado and not on the moist Pacific coast. If, however, the climate in which one desires to plant this tree equals in wetness the Pacific coast, it would be better to secure seeds from that district.

One often hears the argument that trees or any other living thing which have survived adverse conditions are stronger and hardier than they would have been without this struggle. An animal or plant which has been deprived of everything except the minimum requirements for existence, can never compete with the well-fed organism. A tree can never completely recover from the effects of suppression and adversity. The common practise of hardening plants by growing them in poor soil is a mistake. Grow them from good rich seed in good soil, and then if they are planted in bad soil they will grow all the better from their good start in early youth. One might, without doubt, produce hardiness by a long process of selection, extending in the case of trees over a period of hundreds of centuries, but the hardening effect on the individual for a couple of years in the nursery is probably very slight.

It is best, then, to collect your own seed in your own district, from the best trees you can find. In that way, and in that way only, can one be absolutely sure that what he gets is what he wants.

This is often impossible, and then one must do what is next best—purchase the seed from a reliable seed-dealer. All seeds bought of dealers should be carefully tested before sowing, because no seed-dealer, for various reasons, will guarantee his seeds. Let me quote from the catalogue of one of our most reliable seed-dealers: "Non-Warranty of Seeds.—We exercise the utmost care and vigilance in testing all seed sold by us, but owing to uncontrollable influences and accidents (such as bad weather, improper soil, insects, etc.), the best seeds will sometimes fail. We have, therefore, in common with all other large seed firms in the United States—members of the American Seed Trade Association—adopted the following disclaimer: 'While we exercise the greatest care to have all seeds pure and reliable, we do not give any warranty, expressed or implied. If the purchaser does not accept the seeds on these terms and conditions, they must be returned at once, and the money that has been paid for the same will be refunded.'"

Beware of too clean seed. Seed which is absolutely clean should be regarded with suspicion, because, in cleaning the husk from the seed, wounds result which permit the entrance of injurious fungi.

Buy a small quantity or sample of the seed first, then test it.

Good seeds should fill their outer coat, should have a good rich color, should have a healthy smell, and should look fresh and living when cut in half. In many instances good seeds will sink, while bad ones float. Sow one hundred seeds in a flower-pot or box containing good soil. Water enough, but not too much. Keep the box in a warm place. Pull out and count all that germinate. In this way it is possible to approximate what may be expected elsewhere.

A better way is to place a certain number of seeds on a piece of porous paper in a plaster-of-Paris dish about six inches square. This dish should be set in a shallow pan or plate of water. Cover the whole with a bell jar. Keep in a warm place, and by the number which sprout the quality of the seed may be easily determined.

The following relating to seed-testing is from an article by Johannes Rafn in the Danish Tidsskrift for Skovvaesen (Chronicle of Forestry), and the Transactions of the Royal Scottish Arboricultural Society:

Mr. Rafn is a seed-dealer, and we more than agree with him when he says that "this world is not nearly as good as it ought to be, and it happens, therefore, in years when seed is scarce, that old seed is put on the market, and very often at doubled prices,

and I dare say all will agree with me that it is then very useful, by the assistance of the testing establishments, quickly to have this substantiated." By testing establishments he refers to state stations for the control of all seeds sold.

TESTING THE QUALITY OF SEEDS. This apparatus consists of a plaster-of-Paris dish in a tin pie-pan. The seeds which have germinated show in the illustration. It is covered with a bell jar to prevent evaporation.

In speaking of the influence of locality on seed, he says:

"Numerous experiments have shown that the spruce raised from seed from Finland grows too slowly in the insular climate of Denmark, and in the central European lowlands, at any rate while it is young; while, on the other hand, the spruce from the central European lowlands will not thrive far north. German Scotch-fir does not thrive in Denmark, Scandinavia, and Finland, and its cultivation has not given good results in the Baltic provinces, while trees from Scottish-grown seed seem to have the greatest power of resistance in the stormy climate of Jutland. Ciesla r further points out that the spruce and larch from high elevations do not thrive well in the lowlands, while, on the other hand, the lowland spruce can not

thrive in the highlands, and finally, that the Scandinavian Scotch-fir grows considerably slower in the Austrian lowlands than their own native fir.

"All this ought to make it clear to every one how important it is, by the aid of seed-testing, to be able to secure seed from the places that are likely to be most serviceable.

"Exactly the same difference in the size of the seed, according to the place of origin, seems to assert itself on the great areas of North America."

In the testing of seeds, purity from dirt must be first considered, and then the percentage of germination. The real value of seeds means the number of pure and germinating seeds in one hundred. If a sample shows a purity per cent of 80, and a germination per cent of 90, the real value would be $80 \times 90 \div 100 = 72$. In other words, each one hundred pounds contains seventy-two pounds of seed capable of germinating.

The price of seed should be regulated by quality and not quantity. The real value should determine its price. Seeds should be inspected and rated by competent government officials. All seeds containing pernicious weed-seeds should be condemned. Owing to the effects of official inspection, poor European seeds are shipped to foreign countries. This accounts at least in part for the wide distribution and ex-

treme abundance of European weeds in this country. Johannes Rafn claims that the real value of seeds as tested by him varied as follows: *Abies concolor*, Oregon seed, four tests, real value 7.92–50.42 per cent. Colorado seed, seven tests, real value 14.34–60.58. *Abies pectinata*, ten tests, real value 5.68–68.16. *Chamaecyparis lawsoniana*, five tests, real value 7.10–28.48. *Larix europaea*, seed from the Alps, nineteen tests, real value 17.70–56. *Picea alba*, Danish seed, twenty-six tests, real value 10.84–91.09. *Picea excelsa*, Tyrolese seed, thirteen tests, real value 61.19–90.37. German seed, six tests, real value 67.48–90.38. Danish seed, four tests, real value 44.62–76.32. Swedish seed, twelve tests, real value 73.33–97.61. Norwegian seed, four tests, real value 55.16–86.91. Finnish seed, five tests, real value 65.35–97.71. *Picea excelsa borealis*, Norwegian seed, grown north of the arctic circle, five tests, real value 43.25–94.55. *Picea sitchensis*, fourteen tests, real value 16.50–79.12. *Pinus sylvestris*, Scotch seed, eleven tests, real value 41.12–95.62. Swedish seed, five tests, real value 91.98–97.71. Finnish seed, seventeen tests, real value 38.45–92.84. *Pinus strobus*, Tyrolese seed, four tests, real value 63.80–86.44. German seed, eight tests, real value 52.40–86.40. American seed, two tests, real value 62.78–93.70. *Pseudotsuga taxifolia*, Oregon seed, four tests, real

value 58.83 80.93. Colorado seed, seven tests, real value 12.70–86.77.

In the case of deciduous trees, the following are samples of the results of his test: *Betula nigra*, two tests, real value 0.94–33.50. *Betula papyrifera*, seven tests, real value 1.18 17.41. *Fagus sylvatica*, three tests, real value 78.70 94.60. *Quercus rubra*, two tests, real value 58.60 80. In the case of *Salix purpurea*, collected after sixteen days, none germinated.

The above is sufficient to indicate how variable is the value of seeds on the market.

Nothing is more unfair and disappointing to the farmer or forester than to pay well for seed which is partly if not mainly dirt, weed seeds, and infertile kernels. To work long and hard in the careful preparation of the soil, to sow it with care and then to reap weeds because of inferior seed, is enough in itself to account for the fact that the sons of farmers leave the farm and engage in other pursuits.

The amount to sow broadcast on an acre depends upon the kind of seed, the quality of the seed, the rapidity of growth of the young plants, and the dangers to which both seed and plant may be subjected.

Five pounds of pine seed would stock an area as dense as five hundred pounds of oak seed. A person can not afford to be lavish with seeds, although

the larger the quantity sown, the greater the chances of a good stand.

Whenever seeds are sown a suitable germinating-bed must be prepared, otherwise the best of seed will fail. The soil must be loose, and the seed must be covered in proportion to its size.

Forest seeds may be sown with agricultural crops, such as rye or wheat. Furrows may be plowed at intervals of four or five feet. This is an excellent way to start oaks, chestnuts, walnuts, etc. Harrows, grub-hoes, rakes, or spades may be used, depending upon the nature of the soil and the kind of seeds. Pigs often, by rooting, prepare an excellent seed-bed, to which the fine regeneration in the pine woods of our south is often due.

The accumulation of duff on the surface is often a great hindrance to seed germination. The mineral soil should be exposed if possible.

In nature the seed is washed into the soil, or blown by the wind into crevices, but in the majority of cases it fails to find a suitable nidus.

It is impossible to state just how deep every species should be covered. One is safe, however, in covering seed with a layer of earth twice the thickness of its shortest diameter. The layer should be thicker in loose, dry soil, and thinner in compact, moist soil. In many cases it is merely necessary to

scratch the seed into the ground with a harrow or rake.

Willow and poplar seed will sprout within ten days; white pine and spruce within four weeks, and oak, walnut, beech, and maple within six weeks. Some seeds will not germinate until the end of the second year. In such cases it is better to bed the seeds in layers, in a box or barrel, in leaf-mold, for one year, and then sow them the second spring.

In order to have success in broadcast sowing, the conditions must be very favorable. In southwestern France the sand is covered with brush, and the seed of the maritime pine is sown among it. The seed sprouts, and a forest forms without further effort. The species is an unusually hardy one. In the majority of cases it is necessary to prepare the soil and cover the seed.

In some instances it is sufficient to wound or scratch the soil with a rake or harrow; in others, a grub-hoe may be necessary, and in still others, the plow. Tree seed should be sown thinner than wheat. It is a good plan to mix it with dirt and sow both ways in order to get it evenly distributed over the soil. After sowing, it should be raked or harrowed into the soil. Sheep have been used to advantage to trample it in.

Partial sowing is sometimes practised—that is,

the seed is sown in strips or patches, and not broadcast. In almost every woods there are small patches which might be successfully and easily seeded with desirable species.

A good plan is to dibble in the seed here and there. A dibble is a pointed instrument of iron or wood, with a crosspiece arranged so that it will not enter the soil beyond a certain depth. The seed is dropped into the hole, which is easily and quickly closed with the heel of one's boot. Dibbling might be advantageously practised in many of our forests. It is an easy and efficient method of gradually improving a stand by the introduction of more desirable species here and there. The dibbling in of teak seed has been practised with considerable success in India.

Sowing may be done in fall or spring. Nature usually sows in the fall. Spring is probably better because the seed is not exposed to the dangers of the winter. Some seeds sprout in the summer soon after they fall.

On the whole, however, sowing is not satisfactory, and in general it is better to depend either on the planting of young trees or natural regeneration.

The advantages of planting, that is, the formation of forests by the use of little plants or cuttings which have been raised elsewhere, are not fully appre-

ciated. In many places, as on our Western prairies, where no forests naturally exist, there is of course no other way. In regions where the forest consists wholly of undesirable and unremunerative species, it pays in the end to cut clean and plant afresh. In most of our woods the best species have been removed. The forest weeds and the least useful species have been left, and have complete possession of the soil. In order to establish in such places good even-aged stands of the most valuable species, planting is necessary. To be sure, one can gradually improve a very poor forest by careful cutting, and by the gradual introduction of new species by planting here and there, or by dibbling in seed, but the quickest, simplest, and most remunerative way in many cases is to cut clean and plant afresh. Whenever a forest can be quickly regenerated naturally with the species desired, it would of course be foolish to plant; but where one is working on land covered with a lot of undesirable kinds left over from a lumberman's ravages, with no hope of getting it into desirable shape for many years to come, the best way is the shortest and surest—cut clean, and begin at the beginning.

Planting may be practised with all species, but it is especially adapted to tender kinds which require attention in youth, and to species the seed of which

is expensive. The simplest form of planting is by means of cuttings. This is one of the most important means of plant propagation to the horticulturist, because of the ease with which valuable varieties may be increased. With the forester it is only of use in the case of the willows, poplars, mulberries, and a few others. A cutting is a detached portion of the ripened wood of the parent tree. Good cuttings are usually about a foot in length and from one-half to one inch in diameter. These slips or cuttings should be placed slantingly in the ground with a small portion of the tip exposed. A good way to plant cuttings is to plow a furrow, place the cuttings carefully in a slanting position in the furrow, and then run a second furrow to close the first. In case this is not possible, they must be planted with a spade or grub-hoe, or if the soil is soft, placed in a slanting hole made with a dibble, and then pressed tight with the foot. In case the soil is moist enough, poplars and willows will grow luxuriantly in this way. In fact, cuttage is the only way in which they are propagated, because of the difficulty of seedage. If the soil is not fairly fertile and moist it is necessary to place the cuttings in good moist soil first until they have developed roots, and then the following spring plant them where they are intended to remain permanently. The willow is extensively grown in this way for basket material. The Carolina

poplar, which is of value for paper pulp, may be easily propagated from cuttings.

Before planting, we must first assure ourselves of good plant material. Little plants may be secured in several ways. We may grow them ourselves in nurseries from the seed, we may transplant them from the woods, or we may buy them of nurserymen. At first thought many would say that the second suggestion is the best—that little plants could be collected from the woods in places where they are too thick by the millions, that they would never be missed, and that those which remain would be benefited by the increase in room. This is, in fact, such a poor way that it is rarely if ever practised, because it seldom yields good results. Trees from the woods are used to woods conditions, such as shade and leaf-mold, and when removed, unless heavily pruned, sicken and die. They are also of unequal quality and age.

The third method is often practised in places where there are good nurseries, and where the kind of trees needed may be had in large quantity, good quality, and cheap; but in spite of the fact that they may be skilfully packed, they suffer more or less during transportation. The New York State College of Forestry has imported a large quantity of little plants from Germany. They were carefully packed

in sphagnum moss in large willow baskets. In two instances they carried well and have since grown well in spite of their long journey across the sea. In another instance they were delayed, and were in consequence moldy, yellow in color, and had begun already to sprout. The best of these were planted, and many have lived, although in almost every case where the tip had sprouted, the sprout withered and died, and a lateral bud developed into a leader for the following year. This was, of course, a great drawback. Many died, and even those which lived grew with reluctance for some time. The first year a healthy two-year-old plant is planted it grows slowly. It must first establish itself. At the end of the first year, therefore, the terminal bud is not a strong one. It grows slowly even during the second year, but in the third season good, active growth usually begins.

If one raises his own plants there is no delay, no shock in transplanting, and the little plants are already accustomed to the climate in which they will remain until cut for wood. These plants can almost always be raised cheaper than they can be purchased from nurserymen.

A little tree should grow bushy and not spindling at first. This protects the leader from weeds and other injurious influences.

Every farmer should have a permanent nursery

on fertile soil, and so located that it can be easily protected. An ordinary cold-frame would be sufficient to supply a large number of young trees. Whenever in his travels he finds seeds of desirable species he should sow them. In this way, with little expense and little trouble, he may have an abundance of good plants on hand for planting whenever needed.

A nursery should be located where it can be watched, so that birds and small animals will not steal the seeds or injure the little plants. A rich, sandy loam is the best soil for the purpose. This should be carefully worked and freed from roots, stones, lumps, etc. A level piece of land should be chosen so that there will be no danger from washing. The site should be near a spring, pump, or stream, so that watering, if necessary, will not be difficult. The spot should be manured, but the manure should be free from weed seeds. The manure should be composted—that is, manure, humus, or leaf-mold, soil and lime, should be piled in a heap in layers. Then it should be turned from time to time, and thoroughly mixed. This will ferment and rot. It should be kept moist, but not too wet. If too dry it burns and becomes useless; if too wet it loses some of its richness by leaching. Hardwood ashes is also an excellent fertilizer, but it should not be used in too large quantity. The best and cheapest

grade of potash manure is wood ash. It is an all-round plant manure. Hardwood ash contains five per cent of potash, besides phosphate and the carbonates of lime and magnesia. It is Nature's complete fertilizer, easy to handle, and free from offensive odor. When mixed with leaf-mold, which furnishes humus, it is still better. Chicken manure and wood ashes are often mixed by farmers; but this is a mistake, for one neutralizes the strength of the other. Sheep manure is excellent. It is difficult, however, to improve on a compost of manure from grain-fed horses with leaf-mold and lime.

Some prefer to sow the seeds in lines about eighteen inches apart. This is best for broad-leafed species, but in the case of conifers, it is better to divide the nursery into beds by paths between. The beds should be about four feet wide and twelve feet long. If the soil is moist, the beds should be higher than the walks; if dry, lower. On the whole, however, it is better to have beds and paths on the same level. When the bed is higher than the walk, the edges wash down, young plants are washed out, and the bed dries out too quickly. It should be so arranged that each bed can be covered with a slat frame. Plaster laths are good for the purpose. The space between the slats should be the same in width that the slats are wide. This gives half-shade. Each

bed should have a frame-cover which should be supported by four stakes, one at each corner, and the cover should be elevated about one foot or eighteen inches from the ground. This should be so arranged that it can be easily moved on or off. Conifers in youth require shade and protection. In various parts of the world a shelter is formed over the nursery similar to a grape-arbor, so that men can work under it with ease. A grade of light picket fencing, held together by twisted wires and sold by the roll, is extensively used on the east coast of Florida for shading pineapple fields. This would be excellent for small tree nurseries. In tropical countries, especially for rubber and coffee, some of the original forest trees are left standing in the nurseries for shade.

The seeds may be sown broadcast in the bed or in lines about four inches apart. A quick way to make even drills is by means of a batten frame. Several battens may be nailed into a frame so that several drills of even depth and width may be formed at once. This drill-frame may be constructed of various-sized battens, depending upon the depth and width of drill required, which depends in turn upon the kind of seed, varying from one-half to two inches. After the seed is sown the drills may be closed with the hand or rake, or by sifting rich dirt over the surface.

In order to protect these beds against drought and frost, it is well to cover the surface with a very thin layer of litter. Great care must be exercised, however, in selecting material for this purpose, as short straw or hay usually contains the seeds of many weeds. Beds are often ruined in this way. Fine forest litter is not always free from weed seeds. In one case, beds which were covered with forest litter in the fall, were filled with maple seedlings in the spring. Sphagnum moss has been strongly recommended for this purpose.

These beds must be kept free from weeds, and where the little plants are too thick, they should be thinned. At the end of the second year, in the north temperate zone, these conifers should be large enough to plant in the woods.

When larger and stronger plants are needed, the seedlings should be transplanted into nursery rows, where they may have more room. Transplanting does not injure these plants. They are often transplanted several times before final planting in the woods. The more they are transplanted in youth the better they stand it. The roots become bunched, and in many cases root-pruning may be practised if the roots are too long and spindling.

Transplanting is costly, however, and on the whole it is better to plant the two-year-olds direct

from the seed-bed into the place where they are destined to remain to form forests.

It is impossible in this connection to give the details of nursery practise. Much, if not the most of it, must be learned from experience. Almost every species must receive special treatment.

There is a great advantage in having the proper kind of labor. An active boy can do much of it quicker, cheaper, and better than a man. In Europe the women and children do most of this work. When forestry is more extensively practised many girls and boys in backwoods districts of this country may thus find considerable employment.

Planting may be done in both spring and fall. Which is the better time depends upon various circumstances. Many people plant at both times, but spring is usually preferred. In spring the time is often too short when one has several hundred thousand young trees to plant, and labor may be scarce. Just as soon as the terminal bud begins to open it is too late to plant. If a tree is planted when it has already sprouted, the tenderest and most important part of it dies first and dies easily. The planting time may be prolonged by removing the little plants from the bed and heeling them in a cool, shady place so that sprouting is prevented. Where the nursery is in a valley, and one desires to

plant on a high mountain, it becomes difficult. The plants will have sprouted while the ground is still frozen in the mountains. It is necessary to take the plants up the mountain and heel them in. In Switzerland it is often necessary to heel them in the snow. They may be removed from the beds very early and placed in an ice-house. I imported, a few years ago, a lot of basket willow cuttings from Germany. The conditions were such that I could not reach America until the latter part of June. These cuttings were prepared in March, and placed in cold storage in Antwerp until the ship sailed. They were then placed in the ship's ice-house. When I arrived in New York, although the trees were then in full leafage, my willow cuttings were still locked in the embrace of winter. They all grew, however, and are still growing.

A lot of time is lost fussing with plants. There are certain rudimentary principles which must be fulfilled, and when these are fulfilled further attention is superfluous. Success in planting is dependent upon the following rudimentary principles: Remove the plant from the nursery with as many roots as possible. Keep it moist, and protect it from the sun while out of the ground. Plant it so that it will set in the ground, when the earth settles, as near as possible as it was in the seed-bed. Remove the weeds, etc., from its immediate neighborhood.

In the case of some plants great care is not necessary, but with a few which are delicate it is unsafe to disturb the roots at all. In this case ball-planting is necessary—that is, the plant and earth together in a block or ball must be removed.

When the roots are free from earth they must be kept in a paint of mud. In transporting trees nurserymen often puddle them—that is, they dip the roots in a paint of water and clay. This clings to the roots and prevents drying.

On the tract of the New York College of Forestry the writer has found the following method to be very satisfactory. When done carefully and in favorable weather, 80 per cent live:

One set of men are supplied with grub-hoes. Another set (boys will do if available) are supplied with galvanized-iron pails. In these pails a few inches of water is put. The pail is then carefully filled with two-year-old plants from the nursery, placed so that all their roots are well covered with water.

The men are then lined up in pairs, one planter and one grubber. The grubber grubs a soft place eighteen inches in diameter. The grub-hoes are well sharpened before leaving the blacksmith shop each morning, because it never pays to work with dull tools, and the grub-hoe must be often used to cut mats of roots. As soon as the grubber has grubbed the earth

so that it is soft, the planter carefully places the plant in the ground with his hands, as nearly as possible as it was in the nursery, and then with his foot presses the earth tight around it. On they go in line in this way all day and every day while the weather permits. Nothing further is done, and Nature is trusted to give a shower now and then, which usually occurs in mountainous districts in the spring of the year. With large plants more care is necessary.

Some planting is done with an iron dibble. This is quicker, but of use only in soft soil, where there are no weeds and roots. Weeds must be removed from the immediate vicinity of the little plant. Being more vigorous and already well established, weeds, especially grass, steal the moisture and nutriment from the young plant. In many places and with many species, planting in this way would end in complete failure. This would be so in dry, sandy districts and on our Western plains.

In Australia little eucalyptus-trees are grown in short pieces of bamboo. These are placed perpendicularly in the ground, and in time rot and are split by the growing roots. In other places little baskets and boxes containing the plantlets are put in the ground, and in other instances, as with coffee, the plantlet is grown in a block of turf. It is sometimes necessary to plant first, hardy shelter trees. Some

trees, such as the chocolate, demand shade and shelter throughout their whole life.

Success in planting on fresh burns is doubtful. The blackness draws the heat of the sun. In such cases it is best to wait until a young crop of such plants as poplar and birch appear, as in the Adirondacks. In these poplar thickets strips or light thinnings may be cut, and the young plants planted with the grub-hoe. In the case of old hardwood forest, from which the softwood has been removed, it is probably best to cut clean, utilize as much of it as possible, and then burn the rest in piles or windrows. As soon as the land is cleared, then plant. Every district calls for special treatment, depending upon the climate and soil.

The natural regeneration of forests may be effected in two ways—by seed and by coppice. A coppice growth consists of the shoots which spring from the stump when a tree is cut, and of suckers from the roots.

The trees which yield the seed are called mother-trees. In natural regeneration the work of Nature is hastened by man to a certain extent. The seeds are sown by Nature, but man prepares the germinating bed by wounding the soil, and regulates the light by cutting in such a way that speedy regeneration is favored.

In the primeval woods the seeds fell and germinated. Wherever an old tree in falling had admitted light, a group of vigorous young trees would shoot into the air. Old trees long past their prime would prevent the growth of hundreds of young, active trees. These should be removed by the forester, provided they serve no purpose as seed or shelter trees. In many parts of this country natural regeneration is extremely quick and vigorous, although in almost every case it can be improved and hastened by the aid of man. In other districts it is slow; so slow and uncertain, in fact, that planting is preferable.

In a mixed hardwood forest it is difficult to produce the proper mixture without some planting. In the north in many places—the Adirondacks, for instance—the spruce and pine have been removed. The ground is covered with hardwoods. Most of these hardwoods are defective. The hardwoods regenerate themselves without the aid of man to such extent that the conifers have little show. By being favored, the conifers might here and there work in, as in poplar groves, but in order to get a good even stand of these woods it would be necessary to cut the hardwoods and plant afresh. Suppressed spruces, which have managed to merely exist in the shade of the hardwoods, probably seldom develop into good trees. Conifers gradually work their way into birch and

poplar thickets. In other places one meets with fine natural regeneration of pure white-pine and spruce.

Farmers in many parts of this country have followed the excellent plan of leaving seed trees. Many fine stands of pine owe their existence to these seed trees. Clumps of trees left in unhandy or inaccessible spots, furnish seed to other locations. It is indeed fortunate that islands of vegetation of this kind exist.

In order to be successful in naturally regenerating forests from seed, two conditions, at least, are necessary. The mother trees must be capable of producing good seed, and the soil must be in such a condition that it forms a good germinating bed. Seed years must be watched for and cuttings conducted, to admit sufficient light for the seedlings, but not too much, and the ground must be wounded in some way so that the mineral soil is exposed.

This regeneration may be brought about in several ways. Suppose we have a large pine-tree in mixture with hardwoods, which is mature, and which we may desire to cut, but desire also to have it replaced by young white pines. We should wait for a seed year, and just before the seeds fall we should cut away the underbrush and weeds for some distance around the tree, also, perhaps, some of the neighboring trees, so that its crown will be perfectly free.

Then we should wound the soil with mattock, rake, or with any other instrument, or in any other way that may be convenient. If the seeds are not devoured by animals, or are not blown elsewhere, they should sprout in the course of a couple of years. When the young trees are well established, say two or three feet in height, the old mother tree may be removed, and there is left in its place a group of thrifty even-aged pines. This is the group or hurst method of regeneration. Pines and spruces, or any other desirable species, may be thus gradually favored in mixed uneven-aged woods.

An excellent method of regeneration in pure woods is by strips cut in such a way that they will be seeded by the wind from adjoining woods. If we should have a white-pine or spruce woods, we could regenerate it by cutting clean strips at right angles to the prevailing winds, beginning with the leeward side. The strips must not be too wide, however, and the soil must be wounded so that the seed can germinate. Old fields in our South are often accidentally seeded in this way, and swine or cattle trample the seeds into the soil.

Pure forests may be regenerated throughout by a series of successive cuttings, with the final removal of the mother and shelter trees. Gradually and evenly the cuttings are conducted throughout the old

stand in such a way that the new crop replaces the old. The first cutting is conducted when the trees have reached maturity, and are in good condition to produce an abundance of seed. Just as soon as the whole ground is stocked with seedlings, other cuts are conducted to let in more light, but still to leave sufficient trees for shelter. As soon as the little trees are well established the mother trees are completely removed. By this system of regeneration fellings, the old crop is gradually replaced by the new. The cuts should be so conducted that the young crop may be even throughout. This has accidentally occurred where trees have been gradually removed by woodland owners. Unintentionally, pine woods have thus often been splendidly regenerated. In places a few young trees may get the start of others, or have started before the beginning of the regeneration cuttings. This is called advance-growth. Where even-aged woods are desired, this is unwelcome. It may have stood many years in a suppressed yet living condition in the shade of the old wood. It is, therefore, often not capable of developing into healthy, full-sized trees. Where evenness of stand is not especially desired, it is not objectionable.

The methods just described, together with regeneration by means of coppice, constitute the principal means of natural regeneration.

There have developed certain systems of forest management which are classified according to the manner of cutting and of regenerating. Notwithstanding the complexities of these European systems, with their manifold modifications and combinations, the methods of forest treatment may be divided into four systems which are more or less applicable the world over. Each system has its advantages and disadvantages, and must be adapted to the conditions which exist in every instance, and its success, above all, is dependent upon the knowledge and skill of the person who endeavors to apply it. These systems are briefly, as follows:

I. The selection system, which is especially adapted to uneven-aged or irregular protection forests.

II. The system of clear-cutting and then regenerating by planting with young trees, or by sowing the seed, or by waiting until the wind sows it from an adjoining forest.

III. The system of regenerating pure forests naturally by uniformly and gradually thinning throughout, and admitting light in such a way that the seeds will germinate and the young growth properly develop.

IV. The coppice system, where the forest consists of species which will sprout from the stump or the root.

The formation, tending, and cutting of forests with regeneration in view, may be briefly expressed as follows:

Formation.	Tending.	Cutting with regeneration in view.	
1. Direct sowing of seed and planting.	1. Cleaning	I. Clear cutting	Cutting clean, but in such a way that the forest will be regenerated by seed from adjoining woods; or cutting clean, with the purpose of regenerating by direct sowing, or by planting, or by depending on shoots and suckers.
2. Natural regeneration by seed and by coppice.	2. Pruning		
	3. Thinning	II. Selective cutting	Cutting here and there only those trees which are mature or which for various reasons should be removed, but in such a way that each tree cut will be replaced by a group of young ones.
	4. Protecting	III. Successive cutting	Cutting uniformly successively so that the mature stand will be gradually replaced by the young growth, leaving some old trees for seed and shelter.

Since regeneration is an important factor in the classification of these silvicultural systems, and since regeneration is the keynote of forestry, it is proper to define these systems more in detail in this connection.

In the selective system regeneration is conducted throughout the forest irregularly by the removal of the oldest, largest, or defective trees. When the trees which should be removed for silvicultural reasons have no value, and when the condition of the forest does not warrant the expense which their removal

would entail, girdling may be practised. This system is especially applicable to uneven-aged mixed forest. Cuttings are so arranged that groups of little trees replace the old ones. If the forest is large it may be

PLANTING AT AXTON IN THE ADIRONDACKS.

divided into sections, so that a section may be treated each year, or at other stated intervals. A small amount of material is thus constantly supplied, although the cuttings are scattered, and reaping, therefore, is more expensive per thousand than in places where concentration is possible. It is well adapted to small holdings, and is the best of all systems for protection forests, where the exposure of a large area of

soil at one time is objectionable. It is an excellent system for the production of park effects where variety is desirable. In this system the best is constantly favored. It is a process of weeding out the poor kinds and favoring the good. The French, in fact, call it "jardinage," or gardening. It is just the opposite of what has been practised heretofore in this country. In our mixed forests the owner often sells one species to one man and another to another man, and so on till everything of any value whatever has been removed. The tree weeds, or worthless species, with the increase of room and light, grow with great vigor until in time they may have complete possession of the soil. In the selective system, by judicious cutting here and there, wherever possible, and whenever financial conditions permit, the weeds are cut, and the forest is gradually rendered of greater value and of better appearance. To practise this system in an intensive way requires a great deal of skill and a great deal of supervision. One must know well how the different species act in varying quantities of light, since the amount of light determines the amount of seed and the kind of young growth which will follow. It requires, in other words, a knowledge of the science of œcology. This word comes from the Greek *oikos*, a house. It treats of the correlations of organisms inhabiting the same locality. It is, in

other words, prying into the family affairs and neighborly relations of the trees of the forest.

The clear-cutting system does not need much explanation. It means simply that the forest is cut perfectly clean and then regenerated in one of several

MEASURING WITH THE CALIPERS.

ways, but usually by planting. In this system harvesting operations are concentrated. The system is the simplest and in many cases the best from both a financial and silvicultural standpoint. The crop may

be cheaply reaped in this way, and then one can plant whatever he pleases on the place it occupied. No special supervision is necessary. The work may be safely placed in the hands of a contractor. He can do no injury. After the slash is removed, the forester may conduct his plantings. The soil is exposed to the action of sun and wind, and might in some instances be seriously damaged, especially if located on a steep mountain side, or in places where water or wind might do injury. Burning over the soil is often an advantage, especially in northern districts where duff often accumulates to such extent that it interferes with forest-growth.

The successive cutting system is applicable only to pure even-aged forests, or in pure even-aged groups or clumps. When the forest approaches maturity, regeneration is effected by a series of carefully conducted cuttings. These must be begun in anticipation of a seed-crop, and the soil must be prepared in such a way that the seedlings may reach mineral soil. Large accumulations of humus are often a great hindrance to the application of this system in many northern districts. The system is similar to the common custom of leaving seed trees, although the seed trees, in this case, are evenly distributed over the whole area. They are left also for the purpose of affording shelter to the young trees. As the young trees ap-

pear upon the forest-floor, a series of progressive thinnings is conducted, and when the young crop is well

A Corner in the Nursery at Axton.

under way, and no longer in need of protection, the mother- and shelter-trees are completely removed.

The coppice system is commonly practised in our South, where oak and hickory are cut in the pole stage for firewood. Large areas of oak are treated in this way in Europe, mainly for the bark, which is used in tanning leather. Coppice is usually allowed a very short rotation, except, perhaps, in the case of chestnut, which is especially valuable for telegraph and telephone poles. In every case the stump should be very carefully cut with a sharp ax. In the case

of large stumps, rot begins and extends into the shoots. Small stumps often grow over before rot begins. Three shoots may be left advantageously to every stump. If the stumps are cut smooth close to the ground, and with sloping top, the coppice of a few species will grow into good timber. The red-

RIDING THE LOGS IN THE RAQUETTE RIVER.

wood of our West is the only conifer in this country which produces a vigorous coppice. Some of the more promising shoots here and there may be allowed a longer rotation, or other trees may be introduced or encouraged. These are usually called standards, and a coppice-growth with a short rotation, with here

and there trees which are allowed a longer rotation, is called coppice with standards.* The main body of coppice, for instance, may be cut every ten years for fuel, while the standards may be allowed fifty years in order to furnish ties, telegraph or telephone poles, pilings, and in some instances, saw timber.

What might be called a modification of the coppice system is the pollarding and lopping of trees, which is extensively practised in Europe for the purpose of yielding, at frequent intervals, twigs and branches for fuel and various other purposes.

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* In our North the term "standard" is used as a unit of measure. It is a log nineteen inches in diameter at the small end and thirteen feet in length. It contains about 195 feet B. M.

CHAPTER VII

THE TENDING OF FORESTS

Under the head of the tending of forests should be included improvement cuttings and protection.

1. Improvement Cuttings

Improvement cuttings include cleanings, prunings, and thinnings.

The removal of dead, injured, or otherwise undesirable trees from a forest is called a cleaning. This includes in the beginning the removal of weeds or useless species. A weed, in its broadest sense, is simply a plant out of place. Species infested with disease should be removed. Insects breed in dead and decaying timber. Every tree, living or dead, which harbors injurious insects, or fungi, or mistletoes, is a dangerous center of infection. Brush, injurious vines and creepers may do great damage if allowed to seed and spread. When forests have been naturally regenerated, this is very important. After regeneration is complete, cleaning is necessary, especially in tropical countries, where creepers, epiphytes,

and a host of worthless species interfere with the better kinds. Aside from the great good accomplished, the forest is improved in appearance by cleaning, which in many instances is a factor worthy of much consideration. The removal of dead branches might also be classed under the head of cleaning. The value of the timber may be much increased in this way. A dead branch forms loose knots in boards and planks.

The removal of green branches is called pruning. The fewer the branches, the better will be the quality of the wood. Trees should be grown in such a way that they will naturally shed their lower limbs. Trees grown in the open retain their branches close to the ground. The greater the power to endure shade, the larger will be the amount of limbage which a tree develops. On the whole, however, the pruning of green branches is not advisable in the forest except for esthetic purposes, because it is expensive, and if the limbs are large the wound must be covered with antiseptic paint in order to prevent rot. The spores of fungi collect on the wounds and cause decay, which spreads throughout the whole stem of the tree. If the wound exceeds two or three inches in diameter, it should be covered with creosote, coal tar, or paint, which will prevent the entrance and growth of fungi. The cut should be smooth, and great care must be

A Spruce Forest in Germany which has been frequently Thinned.

exercised so that the bark is not split when the limb falls.

As to just what constitutes the cultural operation called a thinning, there is considerable diversity of opinion. I have already defined a cleaning as the removal of all dead, dying, diseased, and distorted stems and weeds. A thinning consists in lessening the crowded condition of the crowns of the good trees in a canopy, so as to provide room for those which remain, as they grow older and larger. Considerable depends, however, upon the meaning of the word "good" in this connection. The good trees may not always be the tallest and biggest. What is good depends upon the nature of the management, and the kind of wood desired. Thinnings should be frequent so that the canopy may be lightly and gradually opened, and not interrupted. As the forest grows in age, the number of trees it is capable of supporting decreases proportionately. As they crowd one another some are strangled and in time become suppressed and die. Nature will do her own thinning in her own way. Man, however, can hasten and improve the process. He aids her in such a way that she can produce better materials in larger quantity and in a shorter length of time.

The difference between a cleaning and a thinning may be rendered clear by the following example: If

in a roomful of men there are several obnoxious persons, their removal would constitute a "cleaning"; if, on the other hand, because of a lack of room the reduction of the number became necessary, the removal of every other person, or every third or fourth person, would constitute a "thinning." In thinning, however, as in cleaning, although the object is primarily the reduction of population for the sake of space, a process of selection may be practised by removing the least desirable members of the community whenever this is possible.

A single tree in the open produces much more wood than it would in the forest. The quality of the wood produced in the open is of course poor. Sometimes only fuel-wood may be the object, sometimes also living knots may be desired to produce a figured board, but this is of course comparatively seldom. The largest amount of poor wood per acre may be produced in the shortest length of time from coppice. A large amount of medium-grade wood may be produced in a comparatively short time in open woods where each tree may have plenty of space in which to grow, and in which there is a large percentage of limbage. The largest quantity of good wood can be produced in a closed forest, where thinning is carefully practised, and where the canopy is kept in such shape that the stems will shed their limbs as

the canopy moves upward with the height growth. The lower limbs die because of a lack of light. The amount of light varies with the climate and the species. In some regions there is an abundance of light. In tropical districts there is too much, in other regions not enough. Some trees grow well in the shade, while others do not. In dry regions, because of a lack of moisture, trees grow singly and seldom form close stands. The object of thinning, wherever it may be practised, is to keep the canopy dense enough so that the trees will shed their lower limbs, and to keep the population of the forest in such proportion that each tree may have room enough to produce the kind of wood desired. The most important part of the tree is its crown. The crown regulates the production of wood. The smaller the crown, the less wood produced. In general, the smaller the crown, until a minimum is reached, the better the quality of the wood. It grows slowly, however, and the limbs are shed while very small. The wood thus produced would be almost without blemish. Time is sacrificed for quality. Such a forest is not as beautiful as a more irregular one. Time also is a very important factor. It pays, therefore, to thin carefully and frequently so that the tree will free itself from branches, and still have crown enough to develop a good strong trunk, and not a long, spindling specimen which would

be unable to stand alone were it deprived of support from its neighbors.

Man may introduce an underwood just as has often occurred in nature. Let us have an overwood of white pine, for instance, a tree which does not clean itself well even in dense stand, because it is a semi-shade-endurer; and after it is well under way, let us plant in its shade maple or beech as an underwood. Let us give to each pine plenty of room, so that its crown will fully develop, and produce a large quantity of wood. The young maples and beeches growing beneath will shade its lower branches so that they will die and fall. In that way the underwood will clean the boles of the pine and will protect the ground, and shed at the same time a rich cover of leaves which will fertilize the soil, and stimulate the height growth of the pine. In this way a good quality of white pine may be produced in a comparatively short time. The soil will improve in quality, and there will be yielded besides a large quantity of hardwood which may be used in the manufacture of barrel staves, wood alcohol, and for fuel.

Much depends upon the species, however. Some trees love a close canopy. Thinning, at best, is a delicate operation. It is work which requires constant supervision on the part of the forester, and the work above all others which tests his skill. Good

judgment is here a requisite. One should keep his forest as uniform as possible. Every tree, from the beginning, should have its proper proportion of room. The actual number of trees which should be removed surprises one. The following table, by Professor Schuberg, shows how much is ordinarily removed by thinnings in the course of years. This applies to spruce, silver fir, Scotch pine, and beech:

Age.	Number per acre.	Space per tree in sq. ft.
20	3,960	11
40	1,013	43
60	449	97
80	346	126
100	262	166

The material yielded by thinnings in many countries more than pays for the cost of the thinning.

Of course, in rough woods, such as exist in this country, in many places where even lumbering is not profitable, it is not possible to practise the finesse of forestry. In wood-lots on farms, however, the farmer may often increase the value of his forest by a little improvement cutting now and then. Often two trees may be too close to one another. If left, neither would develop into a good tree. If one is cut, the other will have opportunity to form a symmetrical crown. Often clumps of trees are so crowded that long, spindling stems have developed. A little thin-

ning, or a series of thinnings, would stimulate growth and wood production. Often one tree may outstrip the others to such extent that its wide-spreading branches may hinder the growth of many promising young trees. These wolf-trees should be removed. And so on, if a man cuts with other purposes than the mere reaping of the wood, he may gradually improve the condition of his forest, increase its productive capacity, and reap, at the same time, considerable useful wood. There will always be an abundance of fuel-wood in this country. Owing to the cheapness and convenience of coal this is not needed. We want good clean timber for constructive purposes. The production of this requires time and skill.

2. Protection

No part of the subject of forestry is of more importance than protection. The protection of all forests, both State and private, against fire and against the careless or malicious actions of individuals, is the duty of the State. This should be controlled by well-enforced laws, and the State should be held responsible. The State owes protection to the persons and property of law-abiding citizens. This function of the State has never been fully performed in the forest districts of this country.

The subject of protection will be divided for con-

venience into the following parts: 1. Protection against fire. 2. Protection against atmospheric agencies. 3. Protection against injurious insects. 4. Protection against grazing and browsing animals. 5. Protection against parasitic plants. 6. Protection against weeds.

1. *Protection against Fire.*—The greatest enemy to the forest in America is fire. With the exception of a few instances, from unavoidable natural causes, such as lightning, fires are caused either directly or indirectly by the carelessness or maliciousness of mankind. Forest fires are by no means confined to this country. They occur to less extent in Europe, but are not uncommon in Russia, France, and Algeria. Fires are frequent in South Africa, Australia, India, and Canada. Sufficient space is not ordinarily devoted to this subject even in European works on forest protection. Statistics relating to fires form unpleasant reading for those engaged in the administration of forests.

Perhaps of all the fires of the world, the conflagration which occurred in Minnesota in 1894 was the fiercest. Not to mention other destruction, six hundred people were killed.

The main causes of fires vary with the district. In general, locomotives deserve first place. Fires thus caused may be prevented by the construction

of the proper kind of fire lanes, the use of spark-arresters, and constant watchfulness during the dangerous season on the part of railroad employees. A host of fires is caused by carelessness on the part of campers and hunters, and by irresponsible and thoughtless persons. A very large number of fires is set accidentally by farmers in clearing land and in burning over meadows. Fires are often set maliciously out of revenge, or for some other ulterior motive. One of the most serious causes of fire, although perhaps not the most extensive, is the time-honored custom of burning over forest land for the purpose of improving the pasture and the blueberry crop. This is a legitimate cultural operation wherever the man who owns the property does the burning. In many instances the land is worth more for this purpose than for forest. Prof. W. M. Munson, in a valuable paper on The Blueberry in Maine, says: "In the southeastern part of Maine, principally in Washington County, there are about one hundred and fifty thousand acres known as the 'blueberry barrens.' Much of this land was burned over by the Indians before the colonial period, and since the timber was removed from the remainder, it, too, has been repeatedly burned to keep down the growth of birches, alders, etc., and to facilitate the harvesting of the fruit." He mentions one tract of forty thousand

acres which is divided into several parts, each of which is leased to some responsible party who assumes the whole care of burning over the land, keeping off trespassers, harvesting, and marketing the crop. Every year a certain section of each "lease" is burned over. This burning must be done very early in the spring, before the ground becomes dry, otherwise the fire burns too deep, the humus is burned from the ground, and most of the bushes are killed. Unfortunately in many districts, especially in the South, the natives burn land which belongs to other people in order to improve the pasturage or the berry crop. There is no doubt that both pasture and berry lands are improved by burning, if the burning is conducted carefully at the proper time of the year. But the custom is a dangerous one for several reasons. It has been practised so long by the natives of our South that they look upon it in the light of a poor man's privilege and not a crime. It has developed in some regions into a custom not unlike the peasant rights of Europe.

Even in forestry, fire may be often used to advantage in ridding the ground of an excess of humus and slash. In the Esterel, in France, where it is difficult to prevent fires at certain times of the year, the forest-floor is systematically burnt over when there is little danger. Every year, from December

to February, patches are burnt over with the object of preventing the growth of weeds and the accumulation of combustible litter. This method should only be resorted to when all others fail. Although fire may be used advantageously at the proper place in the proper time, it is foolish to plant or expend any labor whatever in the way of improvement cutting on forests without having beforehand arranged for ample protection. Forestry is simply impossible in districts where fire occurs.

Fires may be divided into three classes: Crown fires, those which burn in the crowns of the trees; surface fires, those which burn over the surface of the soil; and ground fires, those which burn in the humus and duff. Very often these are united into one sweeping conflagration.

Fires may be prevented by patrols during the dangerous season, by the construction of fire lanes, and by removal of combustible materials, such as slash and litter, from the surface of the soil.

If the forest is large, the telephone is of course of great value. By means of it fires may be quickly located and time saved in securing help.

Roads and trails are also a great help in that they render fires more accessible, and serve as vantage-points in fighting them.

The effects of fire are practically the same all

over the world: impoverishment of soil, destruction of game and its food supply, unhealthfulness, increase of insect pests, in addition to the loss of wood and other property, and injuries to industries which use wood and other forest products.

THE CORNER OF A COMPARTMENT IN A FRENCH PINERY. Showing fire lane in front, and on the left, and clean forest-floor for the prevention of fire.

For the prevention of fire, the punishment of fire-setters and the construction of wide fire lanes along all public wagon-roads and railroads are necessary. Railroad companies should be required to construct lanes, broad and clean enough along their

tracks, to eliminate all danger from flying sparks; to ditch all swamp-lands to water or mineral soil on the outer edge of the lane, and to constantly use efficient spark-arresters on their engines. Similar lanes should be constructed along all public roads. In this way, what are now points of danger, from which the majority of fires start, would become means for the prevention of its spread, and would serve at the same time as vantage-points in combating it. Whenever possible these fire lanes should be kept under cultivation, in other places the brush should be cut, and all combustible materials burned at a time when there is no danger of setting fire to the adjoining woods. Sheep may be used to good advantage on fire lanes in some countries to keep grass and weeds in check.

The usual method of extinguishing extensive fires is by "back-firing" or "counter-firing." This is, however, dangerous work, and should not be attempted save by those who are experienced and capable. Very often the back-fires, set by inexperienced, excited persons, have not only resulted in disastrous conflagrations, but have rendered the skilful work of others of no avail. For the extinguishment of surface fires, shovels and hard work are usually sufficient. It is often possible to beat out surface fires with a green bough or bush. In the extinguishment

of ground fires, or those which burn in the peat of swamps, it is necessary to confine them within certain limits by digging deep trenches.

Where fire constantly burns the litter from the surface, and prevents the formation of young forests, the soil constantly deteriorates, and finally becomes sterile and lifeless—literally lifeless—because the organisms in the soil which cause the decomposition of humus and the conservation of nitrogen are killed.

It is generally recognized in Europe that the construction of suitable fire lanes throughout the forest conduces more to the prevention of great conflagrations than any other institution. These serve as vantage-points in the fighting of fire, and often in themselves are sufficient to prevent its spread. By means of fire lanes the country is cut into parcels, and the danger of great conflagrations very materially reduced. These fire lanes, in order to be efficient, must be wide, clean, and well cared for, for otherwise they are of little use. They should be constructed and kept in order in a way similar to the construction of State roads. The individual benefited pays part, the community a part, and the State the rest. The owner of the land would be benefited and encouraged, and the payment of a slight increase in tax would be a great and permanent investment. Lands which are now a burden would be-

come more valuable, and the capital which is buried therein would increase, and, if need be, become avail-

A Fire Lane in France.

able. The money which the State expended would return a hundredfold in increased resources and prosperity, and would benefit those who are most in need of it.

The State or county or township ownership, or combined ownership, of a system of fire lanes, should be as palatable to the American taste as the State ownership of roads. In fact these lanes may serve at any time as roads, or may be converted into such on short notice at almost any time. In the course of time the whole fire-lane system may be converted into a great road system, which would add much to the value of the land, and increase the value of the wood, owing to the ease with which it could be transported. Once institute a perfect system of fire lanes and patrol under State control, and the number and severity of the fires will be reduced to such an extent that the evil will gradually fade away, and modern systems of silviculture will gradually creep in as the value of wood and land increases.

The greatest damage done by the lumberman is not in cutting the forest. The main purpose of the forest is to yield timber, and most of the wood cut in the past has been overripe. He has left the ground covered with slash, so that destructive fires have followed in his wake. This has prevented natural regeneration. If the destruction due to these fires could have been prevented, Nature would have replenished these cut-over areas long ago. The more the lumberman cuts and the fire burns, the fewer become the

seed trees, and the more difficult becomes the natural regeneration of valuable kinds.

Some species are almost fire-resistant, while others are extremely fire-susceptible. Certain pines, in spite of their resinous nature, are remarkably fire-resistant. The yellow pine (*Pinus palustris*) is a good example. Other species, because of the thickness of their bark, are practically fireproof, and others, especially hardwoods, because of a vigorous coppice-growth, are able to survive, even if killed to the ground. The locust is often used to fringe plantations, because it drops only a small quantity of litter, produces a vigorous coppice, and is not easily burnt. It is used extensively along railroads in Europe. Considering its great usefulness for ties, poles, and posts, railroad companies might plant it with profit along their tracks in forest districts. In case of burning year after year, the weakest species perish first, and so on until only those species are left which are fire-resistant. In a country where wood is abundant and cheap, fires can not be effectually prevented without the co-operation of all hands. The State officials, the woodland owners, the railroads, the courts, and public opinion in general must unite in their efforts to prevent this needless waste. In many parts of our South the forest fire is a sign of spring. It creates no greater sensation than the migration of wild birds. The pub-

lic must be educated, good laws must be passed and enforced. In many States there is no end of fire legislation. These laws are mainly on paper, and serve no purpose whatever owing to a lack of the proper kind of machinery for their enforcement.

Fire protection is the first step in forest conservation. In the British colonies and in France the head of each administrative unit or conservancy possesses the official title of Conservator. The term implies protection and preservation rather than propagation. Conserve the forest—that is, protect it from needless spoliation, and Nature will do the rest. When this is accomplished, the work of the forester will consist in guiding the forces of Nature, lending a helping hand to Nature, and finally, reaping the crop in such a way that regeneration of the proper kind may follow.

2. *Protection against Atmospheric Agencies.*— One of the most important destructive atmospheric agents to the forester is frost. Two very strongly marked geographical lines are the frost-line in the South and the timber-line in the North. Frost may be wide-spread or local, early or late. The leaf- and flower-buds and shoots are killed by late frosts. Early frosts prevent the ripening or maturing of the wood in the fall. The stems of trees are cracked by winter freezing, and young plants are heaved or uprooted by

the frost in spring. Species may be divided into those which are frost-hardy and frost-tender.

The severity of the damage depends upon the species, the age, and the nature of the locality. As a rule, valleys and lowlands suffer more than uplands. Holes or hollows in which there is poor ventilation suffer most. Areas treated in such a way that some shelter trees are left to cover the ground, are less damaged than those which have been cut clean and planted. Good drainage will reduce the danger of frost. By leaving shelter trees and planting strong, frost-hardy species, its injurious effects may be reduced to a minimum.

The conditions of weather favorable to frost are a clear sky, a dry air, and a still night.

In the case of normal leaf-fall, a corky layer forms at the base of the petiole of the leaf. It is during this process that the changes occur in the leaf which produce the gorgeous tints of autumn. When the tender leaf or shoot is nipped by early frost it is killed at once, and in a black and withered condition clings to the twig for a long period of time, often throughout the winter.

In our North a large percentage of hardwood timber is defective in consequence of frost-cracks and ribs. In the case of sudden extreme cold, especially in the spring, the trunks of trees crack open with a

loud report. This is probably due to the fact that the water in the walls of the wood pores is withdrawn when it freezes into little crystals on the interior of the walls of the pores of the wood. The withdrawal of this water causes shrinkage, which is greatest at the periphery and nil at the center. A wedge-shaped crack, often twenty feet in length, is thus formed. Frost cracks are not unlike season checks in logs. The sap escapes from the wound, ferments, and blackens that part of the trunk. This is especially noticeable in the case of sugar-maples. This sap often freezes cold nights in spring, and this tends to pry open the split. The tree endeavors to heal over this wound year after year, and there results in consequence a long bulge or rib on the trunk along the line of the crack. Large sugar-maples in our northern woods which have been injured in this way are very common.

The uprooting of seedlings by ground frost in the spring is often a serious difficulty in nursery work. The water in the soil forms into ice crystals which lift the topsoil and heave the seedlings out so that when the crystals melt and the soil falls back into place, the little plant is left upon the surface uprooted and exposed. In places where the drainage is good this is less apt to occur.

Extreme heat and drought are, of course, injuri-

ous to tree-growth. It is indeed wonderful, however, the amount of heat and drought which some species are able to endure. The best way to meet these difficulties is to encourage the formation of a thick mulch of humus on the forest-floor, and to keep the canopy

A Shifting Sand-Dune on the Coast of New Jersey.

as dense and even as possible. The bark of some species is scorched by the sun, and several species, such as the hemlock, which usually live in the shade of other trees, sicken and die when suddenly exposed to the bright sunlight.

Great damage is done to forests by the winds. Limbs are broken and often large areas are uprooted. The more the forest is opened up, the greater this

danger becomes. Pure forests of shallow-rooted species, such as the spruce, are often leveled to the ground by the acre in this way in Europe. The best way to prevent the wind's destructive influence is to plant deep-rooted species, to preserve protective belts, and to cut with great caution. On mountain sides where the soil is thin, it is often very difficult to prevent serious windfalls. The danger increases as the forest grows older and the limbs grow larger. Insects and fungi enter the wounds which have been produced by the breaking of limbs, and rot soon follows.

Heavy rain often causes considerable damage. In tropical countries the leaves of delicate species are stripped from the branches by heavy downpours of water. Too much rain causes erosion, and helps the wind uproot trees by increasing their weight and softening the soil.

Hail is extremely injurious in some countries, especially in southern Europe.

In northern climates great injury is caused by snow press. Just as some trees by the flat lateral position and pliability of their branches seem especially adapted to windy countries, so do many trees with their conical form and pliant limbage seem well fitted to shed the great mass of snow and ice which forms in northern climates. In many instances

saplings are bent to the ground and broken, limbs are ripped from the trunk, and trees of considerable size, especially balsams and spruce, are either broken and split, or uprooted. The amount of devastation thus caused is often immense.

3. *Protection against Insects.*—In the case of fire and destructive atmospheric agencies, the danger is more or less from without. In many instances it is entirely beyond the control of man. All that can be done in such cases is to institute preventive measures. An ounce of prevention in the case of fire, for instance, is worth a ton of cure. In the case of many great conflagrations which have occurred in this country, human efforts in the way of extinguishment have accomplished comparatively little.

Aside from these exterior destructive influences, some of the insects and other animals, fungi, or weeds of the forest itself, may, for some reason or other, become abundant and destructive. This is usually caused by a disturbance in some way of the equilibrium of the forest.

There are many disturbing influences at work which are constantly causing a readjustment of the neighborly relations of the denizens of the forest. The introduction of a new species of animal may occasion a complete readjustment. The mongoos was introduced into Jamaica to kill the rats. Almost

every animal which lived and nested upon the ground was killed. Snakes, lizards, birds, etc., were either exterminated or reduced in numbers by this noxious animal. Insects increased enormously in consequence of the destruction of their enemies. The mongoos invaded even the hennery.

A professor in Harvard University accidentally let loose a few specimens of the European gipsy-moth near Boston. It increased enormously so that the State of Massachusetts has already expended an immense sum of money in combating it.

In the forest there are usually three grades of insects—the noxious, the neutral, and the beneficial kinds.

Some trees are rarely if ever affected by insect pests; the tulip-poplar, the black walnut, and liquid-ambar, for instance. Others are constantly infested with one or more kinds. It is difficult to find a locust-tree of considerable size which has not been more or less damaged by the borer (*Cyllene robiniæ*).

There are wood-boring and timber-destroying insects; there are defoliators, root, bud, and seed destroyers, and there is an abundance of species such as mosquitoes, punkies, and flies, which render work in the forest at times extremely uncomfortable. The healthfulness of a country may depend upon the presence of mosquitoes, since both malaria and yellow

fever are carried from person to person by these infected insects.

We should encourage the enemies of injurious insects, such as bats, toads, snakes, lizards, birds, fish, and useful insect-eating insects. We should encourage beneficial birds by preventing the depredations of that most noxious of all animals—the man with the gun.

The cleaner the woods the fewer the breeding-places of insect pests. The greater the mixture of trees, the less will be the damage.

It is impossible to do in forestry what is done in horticulture in case of the visitation of an insect pest. If the forest is infested in spots, and there is danger of the spread of the disease, it is best to cut down the wood, utilize as much of it as possible, and then burn the rest.

Trees with weakened vitality fall an easy prey to insect pests, although healthy, vigorous trees are sometimes infested. Some borers are drowned in the sap of healthy trees, so that trees which are sickly, or which have been injured by fire, are first attacked.

Certain species of insects are often reduced in numbers by the use of decoy trees. Trees which are crooked and of little use are girdled. Insects, especially borers, are attracted to the dying tree, and when

they are in greatest abundance the tree is cut and consumed by fire.

Logs cut in the summer must be barked in order to prevent the ravages of bark beetles. This is often necessary in the case of timber felled by the wind.

4. *Protection against Grazing and Browsing Animals.*—An excess of grazing is, of course, injurious to forests; but, as I have already said in another chapter, the damage is more the effects of abusive overgrazing. Animals such as sheep and cattle, if hungry, will prevent the growth of trees, and injure the soil on hillsides by wearing paths which in time induce erosion and landslides. Pastures in which there is an abundance of grass are often invaded by trees of various kinds to such extent that their presence is objectionable.

In many regions there is a constant struggle between the prairie and forest. Wherever the forest must fight fire, browsing animals, and dry winds, the prairie is in time victorious. The damage caused by deer and other browsing animals, and by gnawing animals such as rabbits and squirrels, is insignificant in comparison with the injuries due to fire and insects. Often in nurseries small animals do a great deal of mischief in eating seeds and seedlings. The English sparrow is fond of the terminal bud of young conifers; in fact, almost all injurious animals prefer

to feed upon the most vital portion of the plant. The extent of injuries of this kind varies with the locality, but is seldom wide-spread and serious. Wild animals are already so scarce in many districts that the majority of people are willing to endure the damage they occasion for the pleasure which their presence produces. In spite of the injuries which are often caused by game animals, forestry and game protection go hand in hand. There is no better way to protect game than by protecting the forest. The destruction of the forest means the destruction of the home and food supply of many valuable wild animals. The deer in Europe is practically a domestic animal. They may be seen in abundance feeding on the grass on the fire lanes along the railroads.

In the case of domestic animals it depends entirely upon the purpose which the owner of the forest may have in view. A legitimate combination is not impossible. Some trees are not disturbed by cattle at all, and can be safely planted in pastures provided the animals are not voraciously hungry. Few domestic animals eat the conifers, tulip-poplar, liquidambar, or walnut, although the majority are passionately fond of the mulberry and other species with a sweet palatable juice.

In many countries cattle are fed upon the leaves of trees, and the natives are dependent upon the

A Prairie Scene in Alberta, Assiniboia, Canada.

pasturage which the forest affords. The most objectionable feature to forest pasturage is the fact that the temptation is strong to set fire to benefit the grass at the expense of the trees.

A heavy sod prevents natural regeneration. In forests with a dense canopy sod seldom forms.

Sheep and goats are extremely injurious when in large numbers, owing to the fact that they feed upon a wider variety of substances than do other browsing animals. M. Mélard, in his famous paper on the Insufficiency of the World's Timber Supply, which was read at the International Congress of Silviculture, thus speaks of forests and sheep in Australia:

"Is there any chance that these very insufficient forests will be properly cared for? Unfortunately, the negative may be foretold with certainty in a country which lives by sheep, and in 1896 possessed 89,745,000 of them. There is no possible *modus vivendi* between sheep and forests. In pastoral countries the forests universally disappear. Rules and prohibitions are useless. They can only be enforced in moist years when outside grazing is good. The sheep then multiply, because food is plenty. When the dry year comes the forest is sacrificed. The public interest is asserted to require that the breeders must be saved from ruin at all costs. The forests are opened, the hungry animals fall on the youngest and

tenderest regeneration, and annihilate it. The forest never recovers, but presents many pretty and open glades, which soon become ugly blanks. The next stage is that of a park-like pasture, with a few trees in groups or singly. The end is now at hand. The trees are killed by the trampling of the soil under them, or by the rapping, barking, and bruising they suffer, and the park is succeeded by the bare plain or the naked hillside, cut up by ravines. Sometimes the ruin is completed at once; for the shepherds are fond of extending their boundaries, or 'improving the grass' by burning the forest."

The extent of the injuriousness of grazing to forest-growth is an extremely important question to both our western reserves and the sheep industry. Mr. Gifford Pinchot, in a recent article on Trees and Civilization in the World's Work, says: "The investigations of the Division of Forestry establish two things: First, that in certain reserves (including all of those in California) sheep grazing should be prohibited altogether. Secondly, that in the majority of the reserves limited sheep grazing may, with suitable regulations, be carried on with entire safety to the forest. Such reserves are those of Arizona, New Mexico, Oregon, and Washington east of the summit of the Cascades. In such localities it is purely a question of degree. The finest reproduction of the

western yellow pine I have ever seen was on a sheep range in Arizona, which had been judiciously grazed for over twenty years without a break. On the other hand, as complete desolation as it has ever been my misfortune to look upon, I have seen in the same region on an area once famous for the stand of grass. Overgrazing was the sufficient cause. Unrestricted sheep grazing has this single mitigating character—it destroys itself. The permanency of the grazing industry in the forest reserves depends altogether on its wise and effective regulation by the Government."

5. *Protection against Parasitic Plants.*—Forest trees are often seriously affected by fungus disease. This usually follows when the tree has been injured and is of low vitality. Fungus disease follows fire, and gains a foothold in the wounds resulting from wind and snow breakage. The disease starts from centers of infection, and gradually spreads. By the removal of the diseased trees from the forest this injurious influence may be reduced to a minimum. Various forms of cancer and witch-broom are due to fungus pests. In some cases these fungi have two host plants—that is, live part of their lives in one form on one species, and a part in another form on another species. This is so of the cedar-apple, which causes brown, irregularly lobed excrescences about

the size of chestnuts on the red cedar or juniper, and on the cultivated quince, apple, and other allied host plants causes the so-called rust.

The disease called "damping off" is a serious pest caused by the action of several minute fungus parasites. It causes the tissues of the seedlings to rot close to the ground, and the little plant withers and dies in consequence. It is very common in nurseries, where it causes the death of a very large number of seedlings. It is favored by damp soil, high temperature, and humid atmosphere. It may often be checked by sprinkling dry sand on the surface, and lifting the covers of the seed-beds to permit better circulation of air.

There are many other parasitic plants of a higher order which cause considerable damage. Mistletoes of various kinds infest a wide variety of species in both temperate and tropical districts. A little mistletoe (*Razoumofskya pusilla*) causes witch-broom on the black spruce in Northern districts. The Southern mistletoe infests the black gum, and in the West several species are common on conifers.

6. *Protection against Weeds.*—The control of weeds or undesirable plants is of as much importance to the forester as it is to the farmer. To permit undesirable species to gain possession of the forest soil

would be like gardening without removing the weedy growth. Weeds steal the nourishment and moisture from the soil; they choke out young plants and thus prevent regeneration; they harbor injurious fungi and insects, and are in many ways extremely troublesome. This is especially so of climbing woody vines and of poisonous plants. A plant may be classed a weed in one place and not in another. It may serve the purpose of shelter at first, and then, later, become noxious.

Species of the genus Lupinus were so named from the Latin *lupus*, a wolf, because it was thought that they devoured the fertility of the soil. Nothing could be farther from the truth. Leguminous plants improve the soil. The yellow lupine of Europe is called in Brandenburg "the gold of the desert." It is the woody perennial weeds which are the most troublesome, and which grow with great vigor in the presence of sufficient sunlight. It is often necessary to cut them down to prevent young plantations from complete suppression.

Seeds of leguminous plants, because of their beneficial influences upon the soil, and seeds of plants that yield fruit which attract desirable animals, are often sown in the forest in Europe. One of the most important works of the forester is in keeping pernicious weeds in check, so that the space and nutriment

which they would consume may be more advantageously used.

In many districts clambering vines and worthless briers and bushes often have complete possession of the soil. The various species of grape which mingle with the branches of trees hinder, of course, their growth, but, owing to their beauty and the value of their fruit, their presence is not so odious. It is quite otherwise with the poison ivy (*Rhus toxicodendron*) which firmly clasps the roots, trunks, and branches of trees, and is poisonous to the touch. The swamp sumac (*Rhus venenata*), which is a shrub, and often almost a tree, is abundant, and is also poisonous, causing a distressing dermatitis, which is often accompanied by serious illness. Another class of extremely disagreeable weeds are the climbing, prickly briers of the genus Smilax. The most provoking feature of these weeds is that when their rhizomes have once gained possession of the soil, it is well-nigh impossible to eradicate them. Clothing and skin are torn in handling them, burning only causes them to sprout with fresh vigor, and, if left alone, they soon reach the tops of trees, to which they become inextricably attached. The only way to get rid of them is to cut them down with a bush-hook or machete, and then with a grub-hoe dig up their rhizomes, bit by bit and year after year, until their extermination is com-

plete. In the Isle of Pines there is an extremely poisonous shrub or small tree called *guao* (*Rhus metopium*), which causes large ugly blisters where it touches the skin. The Government should aid in the extermination of these dangerous weeds * as it does in the case of noxious animals.

Grasses are often extremely troublesome, especially in the tropics, where they reach the size and height of trees (bamboos). In many districts there is a struggle between prairie and forest, and if aided by fire or other conditions unfavorable to forest-growth, the grasses of the former are usually victorious.

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* The State of Colorado paid out nearly $200,000 in an attempt to exterminate the well-known loco-weed (*Astragalus mollissimus*).

PART III

THE INDUSTRIAL IMPORTANCE OF FORESTS

CHAPTER VIII

FOREST INDUSTRIES AND PRODUCTS

"How foolishly men destroy the forest cover without any regard for consequences, for thereby they rob themselves of wood and water!"—*Humboldt.*

1. The Utilization of Forest Refuse

Almost every article on forestry assures us that in Europe, where wood is scarce and labor plentiful, every twig is utilized. We are assured also that in America where labor is expensive, and materials plentiful, this sort of industry is unprofitable. American workmen consider such work a waste of energy and time. Of course, it is tedious, but, considering the gains, it must be classed as one of the most important of all forest operations. Nothing is more praiseworthy in the development of modern industry than the careful utilization of almost every product. In many instances the by-product has become the chief

product. In the production of cotton, for instance, the cottonseed oil and meal together form articles of great commercial importance. In the utilization of the small wood of the forest, a different element of society may be used from those who chop the trees and handle the logs. It would furnish employment of a light nature in which youths, and even women, might find employment.

Binding Sticks into Fagots in France.

Whenever no means can be devised for the profitable utilization of such materials, it is of course a waste of time. Many claim that, owing to the abundance and cheapness of good wood, it is foolish to talk of using brushwood and forest rubbish. Good wood may be put to many uses, but if brushwood can be substituted in many instances just as cheaply, and serve the purpose just as well, it should

of course have the preference. The economical utilization of forest materials requires just as much skill and foresight as their production. Nothing could be more incongruous than the manufacture of grape-vine props from the big trees of California. The most successful manager is the man who puts everything to its proper use. Many wonder at the abundance of slash left by the lumberman. The wonder is, however, that American ingenuity has not devised a profitable means for its utilization. The problem simply needs experimentation and the application of labor-saving devices.

The abundance of such materials, many claim, is a hindrance. In case a great variety of uses is devised for this material, its abundance is an advantage in that it insures a cheap and lasting supply. Its utilization will save other more valuable materials. The manufacture of paper-pulp from large spruce logs when small spruce logs will do just as well, is a waste, in that the log is not being used for the purpose for which it is most fit. As forests are better cared for, this waste material will decrease in quantity. The ideal forest is the one in which there is the greatest amount of the best material and the smallest amount of the poorest.

This stuff is chemically and physically the same as large timber. It exists, unfortunately, in the

form of small pieces, which are tedious to handle, and contains a large percentage of bark. If uses can be devised for this material, one of the greatest problems of forestry will be solved. One of the first steps in the development of forestry was the removal of slash. The most economical disposal of this sort of material is a subject of constant discussion even in Europe. Its removal reduces the number of fires and the effects of fire. It renders fire-fighting much easier; in fact, would eliminate the most pernicious feature of American lumbering. Slash interferes with the growth of young trees, and serves as a breeding-place for injurious insects. The immunity from fire and pest which its removal insures, would be worth at least half as much as it would cost to patrol the forest and extinguish the fires during the fire season.

When one sees people picking with eagerness over a pile of garbage, or hauling old iron and old rubber shoes long distances over rough country roads, or practising hundreds of other apparently unprofitable economies, it would seem that there ought arise a use for the millions of tons of cellulose which rot in the woods. It is not the twigs nor the leaves which do the damage, but the tops and limbs, in which there is often a great deal of good pulp and fuel-wood, and, in many instances, saw stuff. The leaves and small

twigs should not be removed, because they rot and enrich the soil. It is the slash and brushwood which menace the forest and prevent the hope of its renewal on cut-over land.

Wood has been so abundant that its proper utilization is just beginning to be considered. The very word "lumber," as has been already explained, carries with it the notion of rubbish.

In a large part of the Old World sticks are cut about a foot in length with an implement not unlike a butcher's cleaver. The sticks are then pinched into a bundle called a fagot. These bundles of sticks are excellent for starting a fire, and are quite as good as the bundles of kindling which are sold in our large cities. If it pays to convert good pine and spruce wood into kindling, it ought pay to convert sticks into fagots. At any rate, there is demand for kindling. The ordinary refuse of the forest in parts of Europe, especially France, is not sufficient to supply the demands for fagots. Various systems of lopping and pollarding are therefore practised. The tall, slender poplars, which are so characteristic of France, are divested of all their side branches for the purpose of furnishing fagots for fuel. One great objection which Europeans have to the American locust is that the spines interfere with the preparation of fagots. These fagots are in great demand at the bakeries, be-

cause they give a hot, quick fire, which produces a thick, brown crust on bread and pastry.

In the case of willows the pollard system is practised. The top is cut back to within a few feet of the ground. These twigs are too valuable to burn. They are used as twine to tie up grape-vines and fruit trees on trellises, and also for baskets, crates, panniers, etc.

Often various species of trees are cut close to the ground every few years. The coppice shoots from the stumps are turned into fagots. It is, however, not only for fuel that these fagots are used. They have other very important uses. Every engineer knows the value of brushwork. When the bundle of sticks is bound with one band it is called a bavin; when two bands are used it is called a fagot. These are called "fascines" by engineers, and are used in building earthworks, filling ditches, protecting river banks, and in constructing dams and jetties. The force of a wave is dissipated by a facing of brushwork. It is broken into hundreds of harmless wavelets.

There are, no doubt, other uses for brush. The time will come when we shall subject it to a process of destructive distillation for the wood alcohol, wood gas, acetic acid, and a host of other useful chemicals which it contains. Even the ashes of hardwood

brush is a product well worth considering. Man has never yet devised a more useful fertilizer.

When there is a scarcity of wood for paper manufacture, this brushwood will be ground into pulp. It is fairly free from hard knots, and is certainly not essentially different from older wood.

For pulp or cellulose there are endless uses. In addition to paper, pails, and other useful objects, the compo-board will come more and more into use. On these compo-boards we can paste choice veneers, thus retaining the beauty of the natural product, being in fact in many respects an improvement. The twentieth century has its possibilities in this as well as in other lines.

Between the brush and common merchantable fuel-wood there is a grade of wood from one to two inches in diameter which is ordinarily wasted, although the best kind of fuel-wood. It can be easily converted into a fine grade of charcoal. This is the kind of wood ordinarily used for charcoal in Europe. It is a great labor-saving fuel in that it needs no splitting, dries quickly, is easy to handle and easy to cut. There is no better fuel in the world than hardwood sticks ranging from one to two inches in diameter.

We have exalted notions in reference to wood, and have always used too good wood for fuel pur-

poses. The fuel question is bound to take care of itself in the regions east of the Mississippi River. If we devote our energies toward the pro-

A Coniferous Forest in Maine.

duction of the finest grade of saw stuff, there will always be slash enough to supply fuel demands. By paying great attention to the production of

first-class saw stuff we will reduce the amount of refuse.

Sportsmen should be especially concerned in the removal of rubbish from the woods, in that it facilitates hunting; in fact, would permit hunting in regions in which it is now practically impossible.

2. The Lumber Industry

Except, of course, in the deserts and plains, there was an abundance of magnificent timber of many kinds throughout this country. It existed in tangled profusion. No wonder the Indian set fire to facilitate hunting. He had little use for the wood. He was, in fact, powerless in its presence with his clumsy axes of stone.

Wood is a peculiar substance. It has endless uses, and is consumed in immense quantities where plentiful. Yet it is possible to live with little wood. Its value depends very often upon the abundance of substitutes, such as coal, stone, iron, and other materials. In Italy an exceedingly small amount of wood is used. The props of grape-vines are often cut from solid granite. Almost every Italian is a good stone-mason, while in this country almost every boy is skilful with hatchet and saw. The Eskimo builds his house of rocks and ice, and warms his body by wearing furs and eating fat.

In many places where wood is scarce, houses are constructed of mud or sods. Cow dung is often dried for fuel even in Germany, and only a few years ago corn was used for fuel in place of wood in Kansas. The great value of wood is due to its beauty and variety, and to the fact that it can be easily worked with tools, and easily held in place with nails and glue. A very important feature of timber is the manner in which it conducts itself toward nails. Some timbers split easily when nailed, while others hold nails tenaciously. One of the virtues of hemlock timber is the way in which it grasps nails. A nail holds a board fast, but the firmness with which it holds it depends upon the firmness with which the wood holds the nail. Some woods are valuable because they prevent nails from rusting. A nail never rusts in teak-wood.

The early settlers of this country were armed with a mighty weapon and implement. It was the iron ax, by means of which the primeval woods were conquered. The American ax has been improved by many Yankee inventions until it is now the finest ax of all the world. Its development has been aided by the presence of hickory for handles. The genus Hickoria is peculiar to North America.

Soon ships were built and sawmills constructed along the streams, and lumber was exported to vari-

ous parts of the world. Railroads soon rendered other regions accessible; huge sawmills were in time constructed, and the great lumber industry was pushed to its utmost to supply the needs of a progressive, wood-using people. It has swept across this country like a voracious monster, and in the great forests of the far West is now having its richest harvest. It is rapidly devouring the substance which keeps it alive. Soon there will be insufficient food material for these enormous mills. The day of the little mill will come again. The industry will be forced to content itself with smaller and poorer stuff until the time comes, as it must come to every progressive, wood-using people, when wood will be protected and exploited in such a way that a constant supply for all time may be assured.

The nature of timber varies, of course, with every locality, and the methods of working it vary accordingly. In the North the white pine has been and is still the king of soft woods. Although Michigan, Wisconsin, and Minnesota are classed as the great white-pine States of America, white pine was once more or less abundant throughout the northern and north-eastern United States, and in eastern Canada. The amount which has been cut must be reckoned in billions of feet, and the amount of capital concerned in hundreds of millions of dollars. The natural range

of the white pine covers the area between the fortieth and fiftieth parallels of latitude east of the plains. It extends southward also along the Appalachian Mountains to the southern limits of Tennessee and North Carolina. It has reached its optimal growth in the latitude of about 45°.

The following in reference to the exhaustion of the white pine is copied from the American Lumberman:

"It is true that white pine had been growing scarcer and scarcer in districts tributary to water shipment, and it had also been known to have been cut out rapidly in the interior of Wisconsin and Minnesota; but never until this year has it begun to dawn upon the minds of distributors of white-pine lumber that there was an actual scarcity of the wood, and that its end was in full view. This year, more than in any year since the development of the Northern pine forests began, has the scarcity of white-pine stumpage and lumber been significantly impressed upon the minds of the people. Witness the hegira of lumbermen to the South within the past year or two. Witness also their western flight to the Puget Sound district, to the California Slope, and to the intermediate districts of Idaho and Arizona."

In the North the owner of timber land usually sells the timber to the lumberman at a certain stump-

age price. The purchaser is concerned only with the removal of the timber. He leaves the ground covered with inflammable slash, and has little or no regard for the young trees which should form the future forest. He leaves few seed trees, and fire and destruction follow in his wake.

In the North the felling of trees with ax and saw begins early in the fall and continues until winter. The trees are converted into logs, and snaked out by teams of oxen or horses to the skidways. When snow and cold weather come, the logging roads are packed and sprinkled with water so that the great sled-loads of logs may be moved with little effort. These logs are hauled to the bank of a stream. When the spring thaw comes and the stream begins to swell, the logs, with the aid of cant-hooks and peavies, are rolled into the water.

These streams are often prepared at great expense. Dams and sluices are constructed, and rocks blasted so that the logs may have sufficient water, and avoid obstacles which would occasion jams.

With the flush of water the drive begins. When all goes well, the great mass of logs glides easily with the current. There must be booms here and there to prevent the logs from backing into sloughs, or into the bushes along the flooded stream banks, and the drivers must be ever alert to prevent the

River-Driving in the Adirondacks.

formation of jams which cause delays and waste of timber, especially when dynamite is necessary for its extrication. A single log may get twisted and cause a tangled mass. The skilful river-driver scampers like a squirrel from log to log, and in spite of danger releases the key log which causes the trouble, and the whole moves on again toward the sawmill.

In this way the logs are floated, or rather driven, to the mill. They move from the water to the saw and pass out in the form of lumber to the yards or cars, and are then transported to the lumber dealers in many parts of the world.

The history of a tree from the time it starts in the forest until the boards which it yields are used, would form an interesting and, in many instances, an exciting story.

Very often, as in Canada, these logs, when they reach larger streams, are tied together and rafted long distances. The common raft consists of a few logs side by side. On this the rafters with their families often live in rudely constructed shanties. These float, sometimes sail, long distances down rivers. Often several such rafts are bound together and towed by tugs. The visitor to Germany will see many such rafts of long straight tree-stems from the Black Forest bound down the Rhine to the Low Countries at its mouth.

Other means of transportation are replacing the river drive. Only those timbers which float high can be successfully driven. Therefore, to properly utilize the forest resources, the river-drive system is inadequate. Furthermore, it fills the stream with bark and dirt, renders the water unpalatable, monopolizes the stream for a large portion of the year, and is harmful to the fish, especially trout and other desirable kinds.

Many and varied are the devices to divest our mountains of their mantle of green. Timber-slides, flumes, cable-tramways, and logging railroads are accomplishing the work with praiseworthy skill, but with destructive consequences.

Thus hundreds of square miles of our northern woods have been cleared of spruce and pine, and millions of young trees are sacrificed in exploiting the timber which is of merchantable size.

Every good tree which grows adds to the wealth of this nation. It will grow on soil which is fit for no other purpose, and yields a material with almost limitless uses. When mature it should be cut and utilized, but waste and destruction is nobody's gain even in the presence of apparently inexhaustible resources. The white pine of the North has contributed so much to the material prosperity of this country, that it seems little more than good business to protect and

encourage the young growth on which we must depend for future supplies.

Inseparably associated with the pine and spruce of the North is the hardy French-Canadian, an excellent laborer, who loves the life of the lumber-camp and the work in the north woods in spite of its dangers and hardships.

The conditions of lumbering in the South differ from those in the North in many respects. There is no snow and no river-driving. The season fit for work in the woods is longer and less rigorous. The country is mostly level, and the trees, as in the case of the yellow pine, are often so far apart that one may drive through the woods without meeting with serious obstacles. In Georgia, for instance, the ground between the trees is covered with grass, and fires are set every year to improve the pasturage.

The trees are not cut into logs in the woods as is the case in the North. The tree-stem, after the limbs and top have been removed, is swung under the axle of two large wide-tired wheels, and hauled through the woods by teams of mules or oxen. The stems are thus partly carted and partly dragged to the railroad or sawmill. At the mill they are converted into floor-boards, finishing-boards, planks, or any one of the many kinds of lumber for which these southern pines are useful. The work of conversion is done

quickly because of the danger of insect and fungus injuries incident to warm climates. The logs are sawn into lumber as soon as possible, or kept in water to prevent checking, and the boards are kiln-dried at once to prevent checking and bluing.

Here the laborer is mostly the negro, who, although perhaps not as good as the Northern workman, is nevertheless good if managed by men who know him well.

Many claim that forestry is, after all, only an improved form of lumbering. It is true, no doubt, that in the change from lumbering to forestry there will be no revolution, but an evolution. One point, however, is certain, that between the lumbering of to-day and what may be called forestry, there is a wide gap, and this gap consists mainly in the fact that the forester protects and fosters the young growth for which the lumberman has apparently no regard whatever.

In the swamp-lands of the South other methods of utilization are practised. Railroads have extensively developed owing to the ease with which they can be constructed, and to the immense amount of labor which is saved by their use. In many places the logs are hauled or jerked out of the swamps to the railroads by steam and wire cables. Where the swamps are intersected by waterways, scows with

A Lumbering Scene in Oregon.

steam power, called "pull-boats," pull the logs through the soft mud of the swamp in the same way. These logs are then transported by boat, or rafted to the mills. This method is practised with cypress and cedar along our Southern rivers and bayous.

The portable sawmill is a compact piece of machinery which may be easily moved from place to place. The mill is transported to the timber rather than the timber to the mill. Where the lumber is to be used on or near the spot where it is cut, this is, of course, a very economical method, especially where farmers, here and there, have small quantities of materials which they may want converted at home for home use. The use of the portable, or vest-pocket sawmill, is destined to increase, especially in countries such as the pine lands of our South, where the number of feet per acre is usually small.

It is in the far West, however, where lumbering runs rampant. In the great Douglas-fir and redwood forests of the Pacific Slope the greatest difficulties have been encountered and overcome. The immense size of the trees and the roughness of the ground have necessitated the development of peculiar methods and special machinery. Everything is done on a gigantic scale. An Eastern lumberman once remarked that he would be content with the slabs from a Western mill. At the town of Madera, for instance

(the word "madera" is the Spanish for lumber), a shipping point in the San Joaquin Valley, the timber is transported from the mountains by a flume fifty miles in length.

It is difficult to fell such trees, difficult to transport them to the mills, and just as difficult to convert them into lumber. Many of these logs are more than ten feet in diameter.

In felling these huge trees an undercut is chopped on one side. Several cutters may work at the same tree at the same time. On the other side a saw is used until the ax- and saw-cuts nearly meet. Wedges are inserted in the saw-cut to force the tree over in the proper direction. It often requires two men full half a day to wedge over a single tree. The felling of such a tree without rendering it useless, requires great experience and skill. Such a mass of wood in falling on rough ground, if improperly handled, would be shattered into useless fragments.

The removal of the bark, which is often eighteen inches thick, is no small job. In peeling such logs wedges and crowbars are necessary.

The logs are sawn into proper lengths, and are then either dragged out by ox-teams or jerked over the ground by means of wire ropes and steam power. The traction engine, commonly called the "tractor," is very extensively used in our Western country. It

is probably, considering all things, the cheapest and most useful power for all common purposes. In the case of very large logs, splitting with explosives is often necessary. Mammoth sawmills have naturally developed to fit such mammoth timber.

Besides the lumber already mentioned, think of the telegraph and telephone poles and railroad ties which extend from ocean to ocean a dozen times! A map of the railroads of this country resembles a huge cobweb. Under the rails there are billions of ties. Think of the piles used in wharf and bridge construction, of the fences around almost every field, of the fuel-wood which is used in cooking our food and warming our houses, and in operating our industrial establishments! Think of the wood used in house, boat, and car construction; of the wood in furniture and agricultural implements; of the wood in barrels, tubs, buckets, baskets, and boxes! The uses of wood are, in fact, manifold. The desk on which I write is of walnut, the trimmings of the room are of chestnut, the floor is of oak, some of the furniture is cherry, mahogany, willow, and what not, the doors are of white pine, the waste-basket is of willow, the wood of my pencil is cedar, the cigar-box on my table is West Indian cedar, my eraser is of rubber, the mucilage on my desk, if pure, is the gum of a tree, the cork in the bottle is the bark of a tree,

and even the paper on which I write is simply wood in another form.

3. Wood-Pulp and Cellulose

It is of interest to note that the word "book" comes from the old Germanic word for beech, because the Anglo-Saxons and Germans wrote on beechen boards before paper was used. Also that the word "library" comes from the Latin "liber," the bark of a tree. The first paper-makers were hornets, which scrape off the weather-worn wood of stumps, rails, and boards, and convert it into a kind of paper out of which they construct their nests.

The amount of wood which is consumed in the manufacture of paper is immense. A prominent New York newspaper uses one hundred and fifty tons of paper daily. One fails to appreciate the magnitude of this amount without actually seeing it in bulk, or taking part in the handling of it. To produce this amount of paper, two hundred and twenty-five cords of spruce-wood are consumed. It requires one and a half cords of wood to produce one ton of paper-pulp. As the spruce ordinarily occurs in our northern mountains it averages about five cords to the acre. Of course in Europe, especially in Saxony and Bavaria, where large quantities of spruce are raised for this purpose, it grows in dense, pure stands. One acre

there produces many times as much as the average acre in this country. Here it is scattered and mixed with other trees. Although there are 3,787,688 people, or 660 to the square mile in Saxony, 26 per cent of this little country is in forest, and most of these forests are pure spruce. The management of these forests is extremely simple. The forest is cut clean when mature, and then planted afresh. In Saxony, the paper-pulp manufacturer is the most powerful ally of the forester, in that he uses the thinnings of the forest, which begin while the forest is still young and continue throughout its whole existence.

The newspaper referred to, and there are many others which use quite as much, consumes therefore, in one year, all the spruce on 16,225 acres of land as it grows naturally in our northern mountains. At this rate our spruce supply will fail in the course of time, and then other woods will, no doubt, be more extensively used for this purpose.

The Carolina poplar is a good paper-wood. It is easily propagated from cuttings, and afterward regenerates itself naturally. Tulip-wood is used in the manufacture of paper for our common postal cards.

Common newspaper material is simply wood, from which bark and knots have been removed, which is

ground into a pulp and then pressed into paper. In the case of cellulose, the wood is disintegrated and the fibers released by means of chemicals.

This material is extensively used in the manufacture of pails and other useful articles. It may be pressed into durable boards; in fact, even into solid doors.

The pulp manufacturer is in a position from which he can not easily escape. His plant represents the investment of perhaps a million dollars, while the plant of the lumberman is worth only about ten or twenty thousand dollars. In consequence of the great amount of capital invested, he must remain in the business for a long period of time or suffer a serious loss when the wood supply is exhausted. The lumberman owns the land not for the land's sake, nor for the amount and quality of timber the land is capable of producing, but for the crop which covers it. He buys it, uses it, and then abandons it. He pays taxes on it only during the process of reduction. The pulpman, on the other hand, is tied to the soil. His heavy investment makes him fearful as to future supplies. For this reason, with commendable foresight, some of the pulpmen are buying the land with the timber, and are beginning to work the woods in such a way that future supplies may be assured. The demands of the future are bound to increase. Cheap paper means

A Sugar-Maple Forest in Northern New York.
The sap is running into kettles which are attached to the trees.

cheap books, and good cheap books and papers mean much pleasure and profit to many people. In the Orient a good grade of paper is manufactured by hand by the natives from the inner bark of the paper mulberry.

4. Maple-Sugar and Sirup

The maple-sugar and sirup industry is of special interest because it is the only forest industry in this country which is scientifically developed. It is also a much more extensive industry than people ordinarily suppose.

Over 50,000,000 pounds of sugar and 3,000,000 gallons of sirup are manufactured every year from the sap of the maple-tree. The State of Vermont is the leader, having produced in one year about 15,000,000 pounds of sugar and 100,000 gallons of sirup. The sugar, or rock-maple, is the principal source of the product.

This is truly an American industry; in fact, we are indebted to the Indian for the first knowledge of it. He tapped the tree, collected the sap, and boiled it in rude receptacles. We practise to-day the same old method, although it has been much improved. The product is of course cleaner and the implements better.

The first products of our forests were peltry,

drugs of various kinds such as sassafras, lye from hardwood ashes, and sugar.

The following is from an old letter printed in The Pioneers; or, The Sources of the Susquehanna, by J. Fenimore Cooper:

"I procured from my friend Henry Drinker a credit for a large quantity of sugar-kettles. He also lent me some potash-kettles, which we transported as best we could, sometimes by partial roads on sleighs, and sometimes over the ice. By these means I established potash-works among the settlers, and made them debtors for their bread and laboring utensils. I also gave them credit for their maple-sugar and potashes at a price that would bear transportation, and the first year after the adoption of this plan I collected in one mass forty-three hogsheads of sugar and three hundred barrels of pearl ashes, worth about nine thousand dollars. This kept the people together, and the country soon assumed a new face."

The old method was to "box" the tree in a rough manner. At the bottom of the cut, or "box," a shingle or hollow reed was inserted, down which the sap trickled into a pail on the ground. The repeated wounds, the fermenting of the sap on the tree-trunk, and excessive tapping, soon ruined the trees. It was then discovered that an auger hole was quite sufficient. At first a hole one and a half inches in diameter

was bored. Now a three-eighth-inch bit is used. The hole should penetrate into the sap-wood only, and should never exceed one and a half inches in depth. Into this hole a neat galvanized iron spout or spile is inserted. On this a covered kettle is hung.

When the buds begin to swell the flow stops; the spout should be removed, and the hole should be tightly plugged with a wooden stopper. One spout to each tree is sufficient. A maple-tree thus carefully tapped will yield an abundance of sap for more than a century.

In the old method an open kettle was hung over a fire in the woods. In it the sap was boiled. When sufficiently evaporated the liquid would granulate into sugar. This was tested by dropping a little upon the snow. This is the "sugar snow" which is usually present at that time of the year.

To-day there are cleaner methods, with spouts that do not rust, pails with lids, modern evaporators, thermometers, and usually a neat little sugar house to protect the workers and the liquid.

The old-time "sugaring off" was equal to the vintage-time of Italy, the grinding season in the land of the sugar-cane, and the corn-shuckings of our Middle and Southern States.

There is great possibility of extending this industry to many other parts of this country. All through

the mountains of the Appalachian system the sugar-maple will grow and produce good sugar and sirup. From it many delicious confections may be produced, and for hot-cakes in cold weather no sirup can equal that of the maple because of its peculiar woodsy flavor.

5. Resin and Turpentine

In the inner wood of pine-trees there are ducts called resin-ducts, which are full of a substance known as crude turpentine or resin. When the bark is removed and the wood is cut, this material exudes in large quantities, and completely covers the wound. Perhaps, indeed, this may be the purpose of this material, because it is not the sap of the tree. It is produced locally in the inner wood by special organs or ducts.

Immense quantities of crude resin are collected in the pineries of our South; in fact, this country supplies a large part of the world's demand.

It is generally called the naval-stores' industry, because these materials are extensively used in filling the seams of wooden ships to prevent leakage; in oakum, which is used in calking, and on ropes to keep out the water and thus prevent rotting. For this purpose tar is used, and this is manufactured in another way, as will be explained later under the head of Wood Distillation.

In the collection of crude turpentine the surface of the tree is scarified for a few feet from the butt. At the bottom of this blaze a deep cavity is cut. This is called "boxing." Into this cavity the crude turpentine drips from the wound above.

The material as it escapes from the tree consists of resin, which is dissolved in the spirits of turpentine. On coming in contact with the air some of the turpentine evaporates, so that the resin is left in a more or less fluid condition, depending upon the amount of turpentine which it contains.

The crude resin is collected and transported to the distillery, where the pure resin and turpentine are completely separated. In consequence of such treatment the tree dies in the course of a few years and blows down, burns down, or is cut for lumber.

Although this country has for many years supplied a large part of the world's demand for these extremely useful substances, the industry is doomed in time to destruction unless there is a change in the manner of exploitation. In the pine forests of France, a very different method is practised. The tree continues to yield crude resin for a long period of time, and is only slightly, if at all, injured by the process. Instead of scarifying the whole side of the tree and cutting a deep cavity at its base, the French in Gascony cut a narrow groove, which is lengthened

each year, and at the base of which a small earthenware pot is fastened in which the crude resin collects. This groove grows over in time and another is cut on another part of the tree. The tree is not injured by this process, and the products are of better quality. Other trees produce other kinds of useful resins, such as Canada balsam, spruce gum, Venetian resin, and even amber is the resin of an extinct conifer.

Turpentine is extensively used in the manufacture of paints and varnishes, and to a limited extent in medicine. Resin is used in the manufacture of soap, varnish, wax, cement, paper-sizing, etc.

This industry has gradually moved southward, and will last, of course, as long as the yellow and Cuban pines last, but their days are numbered unless more careful methods are practised, although they still exist in more or less abundance over an immense area of territory throughout our Southern States.

6. Tanning Materials

The process of converting hides into leather by the use of tannic acid is called tanning. Tannic acid is very abundant in the vegetable world. It is yielded by leaves, wood, and fruits of many trees. Oak has been extensively propagated for a long period of time in Europe because of the value of its bark for this purpose. Immense quantities of hemlock bark have

been used in this country. The tan-bark industry was of such importance at one time in the eastern United States that hemlock-trees were cut and stripped just for their bark. The wood was allowed to rot in the forest. Owing to the scarcity of hemlock-trees, and to the introduction of other tanning materials from southern countries, the industry is no longer of so great importance.

Quebracho-wood, from which tannin is extracted, is now shipped in large quantities from South America to Europe and this country. When this supply is exhausted, other tannin-yielding plants will be utilized. The black mangrove-tree (*Avicennia nitida*) of the tropics is rich in tannin and extremely abundant, although located in unhandy and unhealthy places.

7. The Destructive Distillation of Wood

A forest industry which is growing in importance is the destructive or dry distillation of wood. A retort is filled with wood. Under this there is a furnace. After the retort is filled a cover is tightly adjusted. Leading from the lid there is a tube which is coiled or zigzagged, and over which cold water runs during the process of distillation. The wood is heated to a temperature of from 600° to 800°, depending upon the kind of wood.

The water in the wood is first driven off in the form of steam by the heat. A gas called wood-gas is also produced. This may be used for illuminating purposes. It is usually conducted back into the furnace by means of a small pipe. A deep-brown liquid, with the flavor of tar and smoke, is produced. From this a great variety of useful chemicals is manufactured. Charcoal, which is almost pure carbon, remains behind in the retort when the process is complete. The products are practically as follows: uncondensable gases, tarry matters, pyroligneous acid, and charcoal. Most of these products are useful in the arts. The acetic acid, or pyroligneous acid, is purified and sold as vinegar. The wood spirits, or wood alcohol, is used for many purposes. It is similar to the alcohol of whisky and brandy, except that it is poisonous, although in diluted form it is used as a beverage in parts of the Orient.

In the case of the distillation of the heavy pine-woods, a large quantity of tar is produced. In the old-fashioned method of tar production the wood, especially the fat-wood and pine-knots, were collected and put in a kiln. This kiln very often consisted of nothing but a pit in the ground on a hillside, into which the wood was put. To the top of this a fire was set. The heat caused the tar to ooze out of the wood and trickle down to the bottom and out through

a tube into barrels fixed ready to receive it. In this old-time method many valuable products were lost in the smoke.

The modern method of wood distillation is a very economical and at the same time simple method of charcoal manufacture. In this way wood of little value, such as knot-wood, and crooked branches, may be utilized to good advantage. Wood contains many chemicals, varying with the species of tree, some of which may be used in divers ways. Charcoal is an excellent fuel for cookery, in that it emits no disagreeable odors. It is almost exclusively used in warm countries, because it can be used in braziers and small portable furnaces, and does not necessitate the use of a stove or the construction of a chimney.

8. Other Common Forest Products

In addition to the products already mentioned, forests yield many other useful articles. Bark is often woven into rope. Cork is the outer bark of an oak-tree which grows in the region of the Mediterranean Sea. The flowers of the magnolia, evergreen branches such as the holly, and Christmas trees are sold in immense quantities in our large cities. Several trees in this country yield edible nuts which are of great value, such as the walnut, pecan, and chestnut. In Southern Europe the chestnut is a very

important food material. Chestnut flour is extensively used in the making of bread. In every part of

THE FLOWERS OF MAGNOLIA GLAUCA.
From "Garden and Forest."

the world the forest yields a great diversity of products. It is in the tropics, however, where the greatest variety of useful materials is produced.

CHAPTER IX

FOREST TREES AND PRODUCTS OF THE TROPICS

"Of the wheels of public service that turn under the Indian Government there is none more important than the Department of Woods and Forests."—*Kipling.*

How little we really know of the vast resources of the tropics. The woods of the Amazon Basin have an almost priceless value. "Nowhere in the world," says Agassiz, "is there finer timber, either for solid construction or for works of ornament; and yet it is scarcely used even for the local buildings." Probably one-half of the whole land surface of the earth is between the tropics, and fully one-half of this has hardly been explored. The very richness and luxuriance of the tropical forest has hindered its development. Civilization, in spite of the cold, or rather with the help of cold and fire, could use to better advantage, in the beginning, the great coniferous forests and the grain and grass-yielding plains. The conquest of the tropics is the work of the future. The trade between east and west is between countries of practically the same

capabilities. The trade or exchange between north and south is destined to increase enormously. It will be the exchange of products of two unlike zones. The soil of the tropics is soft, and encumbered with luxuriant weeds. Transport is difficult, and efficient labor is often scarce and hard to handle. On the other hand, there is less danger from fire. Nature is most bountiful, and the number and variety of species of woods and other products are enormous. Capabilities are here, in fact, limitless, but proper development will require the application of much energy, skill, and patience.

Think of the great myrtle family, including about 2,800 species, some of which are the most valuable plants on earth! Think also of the order Meliaceæ, including about 550 species, many of which have no equals as timber-producers!

Think of the mahwa-tree (*Bassia latifolia*) of India. Few, except those who have visited the Orient, have ever heard of it. Yet it yields a never-failing crop of food, wine, and oil to many poor people, to say nothing of the countless other creatures which feed upon it. Birds and squirrels feast in the branches by day, and at sunset the pea-fowl and deer of the jungle steal out to feast on its succulent corollas. From the flower of this tree intoxicating spirits are manufactured to such an extent that on the island of

Caranja alone the duty collected by the Government amounts to £60,000 per year. From the fruits an oil is expressed which is worth about $175 per ton for the manufacture of soap. But few of us have heard of one of the most famous trees of India—the champak. This is a beautiful tree of the magnolia family, with sweet-scented flowers and valuable wood. It is one of the sacred trees of India, and is planted around the temples of the Brahmans and Buddhists. The flowers, when dried, form the commonest drug of India. Most of us know the clove-tree, a native of the Moluccas, but cultivated extensively in Zanzibar, the unopened flower-buds of which form the spicy cloves of commerce. The petals of the ilang-ilang (*Cananga odorata*) and other trees of the tropics are of great value for perfumes.

An extremely handsome tree is the allspice, or pimento, of Jamaica. The pimento plantations, or walks, as they are called in Jamaica, are formed in the following way: A piece of woods containing a few pimento-trees is cleared of all wood except these trees. This wood, however, is allowed to remain upon the ground and rot. Soon young pimento-trees appear here and there, and at the end of about two years the ground is vigorously cleaned of all rubbish and brush so that the young pimento-walk may grow without hindrance. The berries are collected while green,

soon after the fragrant blossoms fall, and after drying, constitute the allspice of commerce.

Of the many tropical nuts only two are well-known to northern people. These are the Brazil-nut and the coconut. The Brazil-nut is yielded by a majestic tree of the Amazon Valley. The nuts are formed in a hard, round shell, about twenty in number. The shell is six inches in diameter, and so hard that an ax is used with which to crack it. The collection of these nuts is a festival-time for the Indians, who pack them in baskets and ship them down the great river in large quantities to the city of Para. There often comes with the Brazil-nuts a smaller, finer-flavored nut. It is the sapucaia-nut. Although very similar to the Brazil-nut, it is formed in an urn-shaped vessel, six inches in diameter, with a lid at its tip. When the nuts are ripe the lid flies off with an explosive pop. This fruit is sometimes called monkey-pot, and its scientific family name is *lecythis*, which is Greek, meaning oil-flask. The full name of this tree is *Lecythis zabucajo.*

With the coconut we are all familiar. Although an extremely beautiful and useful tree it yields wood of inferior grade. This is so of the palms in general, although palm-wood and palm-leaves are extensively used in tropical countries by the natives for house construction. The trunks of palms are usually

spongy in the center. The outer wood of the coconut-palm is called porcupine-wood, because when cut in a certain way the fibers resemble the quills of the porcupine.

The production of coffee and chocolate should be classed as forest industries, because they are shade-demanders, at least in youth, and grow well under forest conditions. This is especially so in the case of the chocolate. In Trinidad a tree called *Erythrina umbrosa* is used so much to shade the cacao-trees that the Spanish natives call it the "Madre de Cacao," or the mother of the chocolate. It is, however, more of the nature of a nurse than a mother tree. The seeds of the chocolate, which are about the size of a chestnut, are formed in a gourd-like pod which hangs from the trunk and larger branches. These "beans" or nuts, or, to be accurate, "seeds," are removed from the pod, carefully cured, and then shipped north to be converted into various grades of chocolate.

The term "nut" is very loosely applied. It is often used for want of a better term. It usually means a seed with a hard shell which does not open when ripe. In this category are classed many dissimilar seeds, such as the coconut and chestnut. Another peculiar "nut" is the "musk-nut," or nutmeg, a well-known forest product. The fruit con-

sists first of an outer covering similar to the black walnut. The next coat is a network of aril, which forms the mace of commerce. Then there is still a thin shell which contains the hard, rich seed. This is the common nutmeg. Mr. H. O. Forbes, in his book entitled Naturalist's Wanderings, describes a visit to the nutmeg groves of Banda, in the Spice Islands of the East Indies. He speaks of finding himself, after only a short walk from the town, "under a delightfully shady canopy of tall kanari-trees and among the groves of nutmeg of which Banda is the famous garden."

Similar to the chocolate is the cola-nut of Africa, which is being extensively cultivated in the tropics. The product is used in a similar way, although it is claimed that cola is a choicer product than chocolate or coffee. The nuts furnish a nutritious and stimulating beverage rich in caffeine, the active principle of coffee, and theobromine, the active principle of chocolate. They contain more starch and less oil than chocolate, and are therefore more easily digested. The citrate of caffeine which is used in seasickness and nervous complaints may be readily obtained from cola. If half that is claimed for this product is true, it must be rated as one of the most valuable trees of the tropics.

By far the most useful product of the tropical

forest is the caoutchouc, or crude rubber. This material is called india-rubber because it came originally from India, and "rubber" because it was first used for rubbing out pencil-marks. Caoutchouc is the South American name. The great value of this substance is mainly due to its impermeability and marvellous elasticity. It is produced in immense quantities by several species of trees throughout the tropics. It is the juice or milk of the tree, which is collected and prepared in many ways.

The common rubber-tree, which is used so extensively as a pot-plant in our houses, which grows month after month without dropping its rich, glossy leaves, with its roots crowded in little pots, and with an amount of abuse that would kill many of our native plants, is none other than the rubber-tree of the East Indies which has yielded part of the rubber of commerce.

The greatest rubber port in the world is at Para, a large city at the mouth of the Amazon. It is the valley of the Amazon which produces a very large proportion of the best rubber of the world.

The tree which yields South American or Para rubber is called *Hevea brazilensis*. The milk from which it is formed comes from ducts in the inner bark. The collectors are Indians, each of whom carries a small ax and a ball of adhesive clay. With his

ax, as high as he can reach, the collector cuts a deep gash in the tree. Under this he sticks with his clay a small earthenware cup. On the same tree, day after day, he cuts many gashes and collects with care the quota of milk-white juice which each gash yields. Every day he trots from tree to tree, the quicker the better, and empties the contents of the cups into a kettle or calabash.

The calabash is the fruit of a tree, about the size of a melon, with a shell so hard and yet so light that it forms an excellent ready-made vessel in which to carry liquids.

When he reaches his hut with the milk he kindles a fire of wood and palm-nuts in a bottomless clay jug or pot. This is placed on three small stones so that a draft is produced, and there pours from the nozzle in consequence a stream of hot, white smoke. The milk is poured gradually upon a paddle, which is turned in the smoke until the gum changes its color and coagulates into rubber.

This is hung to dry in the sun for a few days, is then sent to Para, and then to other parts of the world to be manufactured into bicycle and wagon tires, overshoes, coats, mats, belts, hose, and a host of extremely useful articles.

The Brazilian rubber-tree in a suitable climate grows rapidly. One tree in Ceylon grew to be six

feet seven and a half inches in diameter, three feet from the ground, in seventeen years.

Another great rubber-tree is a native of Central America and Mexico. It yields the Panama rubber of commerce. It is known to botanists as *Castilloa elastica*. The family name of this tree is a modification of the word Castile, a province in central Spain. This species is being extensively cultivated by Americans in southern Mexico, especially on the Isthmus of Tehuantepec.

A valuable substance similar to caoutchouc, called "balata," is produced in the northern part of South America. It is the juice of the inner bark of a large tree, called by botanists *Mimusops balata*. The Dutch of Dutch Guiana call it "paardenfleisch," or "horseflesh," because of the color of its wood. The milk is drunk by the natives, and when diluted with water is used as cow's milk. Balata is mixed with true rubber for various purposes. It is also used in the manufacture of beltings, and it is said that it may replace gutta-percha, which is now scarce, for purposes of insulation.

Very few species of plants yield good rubber. Many plants are called rubber producers, but the product is usually of low grade in consequence of the presence of resin. The Brazilian rubber, which is the best, grows in regions unfit for human habitation.

The Central American rubber is the species which will be most cultivated in the future, because it will grow on the uplands on well-drained soil.

Milk is manufactured in the tropics from the albumen of the coconut. The white albumen is ground extremely fine, and mixed with sufficient water to give it the consistency of cream. It is then used on fruit.

A common tree in the Sandwich Islands is the candle-nut, from which ten thousand gallons of oil are annually produced. This is a good drying oil for paints.

There are hundreds of tropical trees which produce oils, tanning materials, and medicines of many kinds. The most important of all medicinal trees is the cinchona. This is the tree which yields Peruvian bark, from which quinin and other valuable alkaloids are extracted. It was named for the Countess of Chinchon, vice-queen of Peru, who was cured of the fever by the use of its bark. It is a native of the valleys of Peru, but is now cultivated throughout the tropics. The exploration and settlement of many fertile tropical districts would have been impossible without it.

A very valuable genus of trees for the tropics is the Eucalyptus. There are many species adapted to many soils. They are natives of Australasia, but are now common throughout the warm regions of the

world. Several species reach an enormous height, and grow with wonderful rapidity. It is generally believed that in swampy districts these trees prevent fever. Certain species consume large amounts of water, and thus drain the soil, while others grow in dry regions. They yield an oil which is used for many purposes.

Tropical forests produce numerous dyewoods, one of the most important of which is Brazil-wood. The word "Brazil" means dyewood.

Another valuable dyewood is called camwood. This material is shipped in large quantities from Western Africa to England for the same purposes as Brazil-wood.

Another important dyewood is logwood. Its scientific name is *Hæmatoxylon campechianum*, which translated means "redwood from Campechy." It is common in the West Indies, Central America, and Mexico, and is shipped in large quantities to New York.

An interesting tropical tree is the gamboge-tree. Gamboge is a yellow dye and water-color. The word is a corruption or change of the name "Camboja," which is Cambodia in India, whence it comes. A spiral incision is cut half-way round the tree, and at the end a joint of bamboo is placed ready to receive the juice. When the joint is full it is heated,

and the juice hardens into the gamboge sticks of commerce. The genus Garcina, to which the gamboge belongs, consists of several valuable species. The delicious fruit called mangosteen and other fruits and nuts belong to it.

A very valuable East Indian product is camphor. Its scientific name is *Cinnamomum camphora*. To this same genus belongs the cinnamon of Ceylon. Formosa is a great camphor island. The industry is now in the hands of the Japanese, who became the possessors of this island after the war with China. The tree yields also excellent timber. It is a most beautiful tree, growing to a large size and living to a ripe old age. The flower is white and the fruit a small red berry. In order to extract the camphor the tree is cut down and converted into small chips. These chips are boiled in water. The camphor passes off with the steam and congeals in the form of white crystals in a cool chamber or condenser. Five million pounds are exported every year from Japan. Carved chests of camphor wood to keep out insects are common in the Orient, especially at Hongkong and in the Philippines.

In addition to those which have been already mentioned there are many other valuable tropical forest products, the most important of which are timbers and precious woods.

One of the most valuable East Indian woods is teak (*Tectona grandis*). It is highly prized in England for ship-building, car construction, and ornamental work. It is the most important tree of Java and India, and has been for many years a royal tree. By "royal tree" is meant a tree which, because of its superior qualities, has been reserved from time immemorial for the sole use of the Government or ruling personages. No native of India could cut it from the public domain for his own use. The wood has a pleasant aroma, and rich brown color. It is exceedingly durable and strong, does not crack, warp, rust nails, or shrink, and takes a handsome polish.

A wood which is shipped north in large quantities from tropical America is lignum-vitæ. This is one of the hardest and toughest of all woods. It is used in the manufacture of ship's blocks, pulleys, bearings in machinery, tenpin balls, etc.

Various woods are known as "lancewood," which is used for carriage shafts, whip-handles, tips of fishing rods, spars for small boats, etc., because of its lightness, strength, and elasticity.

A heavy black wood familiar to all is ebony. So heavy is it, in fact, that it sinks in water. This is true of many tropical woods. Ebony is the heart-wood of several species of persimmon, the best of which is *Diospyros discolor* of the Philippine Islands.

We always associate heavy densely fibered woods with the tropics, but some of our finest light woods grow there also. The best of these is the Cuban cedar (*Cedrela odorata*), which is extensively used for cigar-box manufacture, as a finishing wood, and in boat-building. This is not a true cedar. It belongs to the order *Meliaceæ*, which includes many other valuable timber species. It is a broad-leafed tree, and in no way resembles a cedar except that the wood is aromatic and faintly red in color. The tree resembles the English walnut. We have, in fact, no true cedars in North America. The true cedars belong to the genus *Cedrus*, and are well represented by the deodar of India and the cedars of Lebanon. The West Indian cedar is a very rapid grower and produces a very useful and valuable wood. To this same order belong the satinwood of India (*Chloroxylon swietenia*), the redwood (*Soymida febrifuga*) of Coromandel, the toon of India (*Cedela toona*) or the red cedar of Queensland, the African mahogany (*Khaya senegalensis*), and the king of all woods, mahogany (*Swietenia mahogoni*).

All are familiar with this hard, fine-grained, rich reddish or yellow-brown wood, which is used so much in cabinet-work and is known in all parts of the world by its Indian name, mahogany. The tree is a native of the West Indies, Central America, and Mexico,

and is one of the most majestic of trees; for although others may rise to a greater height, the mahogany, like the oak and cedar, impresses the spectator with the strongest feeling of its firmness and longevity. In the rich valleys among the mountains of Cuba, and those that open upon the Bay of Honduras, the mahogany grows to such perfection that it is difficult to imagine a vegetal production combining in such a degree the qualities of elegance, strength, and usefulness. The tree is, in fact, just what one would expect of such a wood. If the time ever comes when forestry is practised in the great fertile, tropical wilderness to the south of us, this tree and the Cuban cedar will deserve first place.

Many other important tropical forest trees might be mentioned; many have yet to be named and tested, and many no doubt will have special uses because of their peculiarities, which are not known now, but will be known some day when physicians discover the causes and cures of fevers which at present infest these regions to such extent that even exploration, not to mention exploitation, is dangerous.

PART IV

SUPPLEMENTARY

CHAPTER X

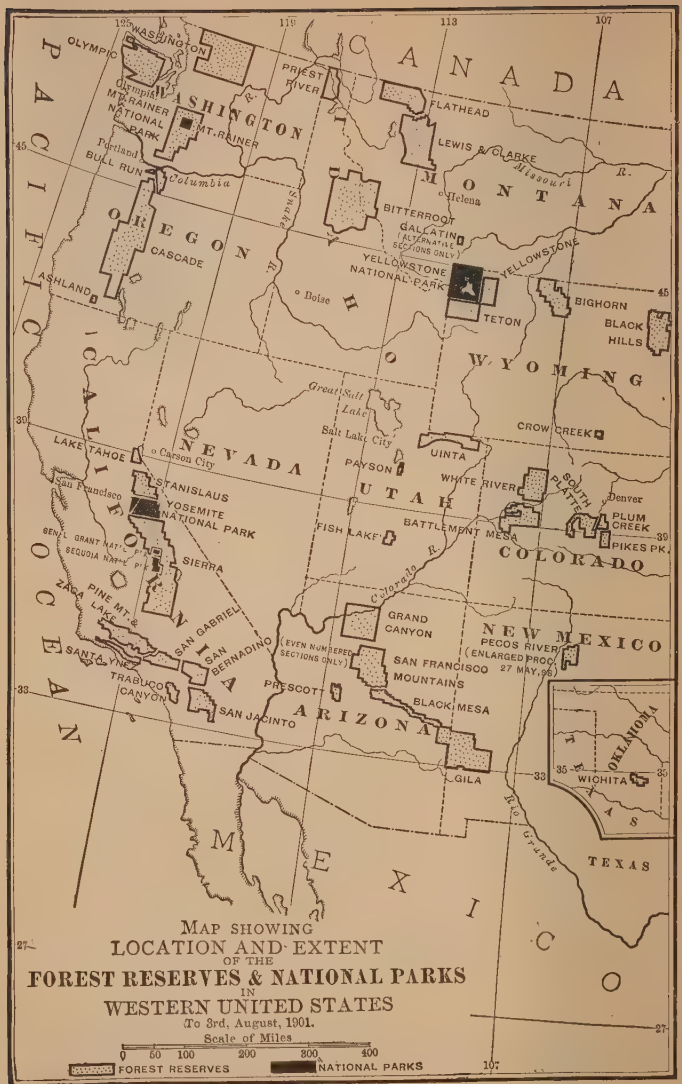
THE PRINCIPAL FEDERAL AND STATE RESERVATIONS

"Some, at least, of the forest reserves should afford perpetual protection to the native fauna and flora, safe havens of refuge to our rapidly diminishing wild animals of the larger kinds, and free camping grounds for the ever-increasing numbers of men and women who have learned to find rest, health, and recreation in the splendid forests and flower-clad meadows of our mountains."—*President Roosevelt.*

The following is mainly compiled from the reports of the General Land Office, the United States Geological Survey, and the Bureau of Forestry of the Department of Agriculture.

In general, North America may be divided as follows:

The Atlantic and Gulf Coastal Plain, beginning with New Jersey and extending southward along the Appalachian chain and westward to the Texas Prairies and the Ozark Highlands. This is the land of the Southern pines; but wherever the soil is not too sandy there are dense growths of many spe-



MAP SHOWING
LOCATION AND EXTENT
OF THE
FOREST RESERVES & NATIONAL PARKS
IN
WESTERN UNITED STATES
To 3rd, August, 1901.

Scale of Miles
0 50 100 200 300 400

FOREST RESERVES NATIONAL PARKS

From "Our National Parks," by John Muir. By permission of Houghton, Mifflin & Co.

cies of hardwoods, especially in the swamps and along the river courses.

The second great district includes the St. Lawrence Basin, Southern Canada, and the Appalachian system of mountains and extends westward to the Prairies. In this district many deciduous species and conifers grow well.

The third great district is the Prairies, where trees do not grow naturally, except here and there and along streams, but where, with care, they can be induced to grow, and when once established continue to thrive.

West of the Prairies are the Arid Plains and Basins, practically desert, where trees do not grow without irrigation except in high mountainous districts of the Rockies where there is sufficient moisture.

The next district is the Pacific Coast Region, where, owing to an abundance of moisture and warmth, there is a very luxuriant growth even as far north as Alaska.

The next district is the Sub-Arctic Forest, which extends across Canada to Labrador. It consists mostly of conifers of slow growth and of little value.

Then away southward in Central America, Mexico, and the West Indies there is the Great Tropical District in which frost never occurs except on high

mountain peaks, and in which, where moisture is sufficient, growth is constant and extremely luxuriant.

Most of the Federal forest reservations are located on the Pacific Coast and in the mountainous districts of the arid regions.

By an act of Congress, approved March 3, 1891, the President of the United States can withdraw from sale and entry and set apart by proclamation parts of the public domain. These are called Forest Reservations.

Presidents have used this power freely, so that the area reserved, including national parks, approximates in round numbers 50,000,000 acres. Owing to the facts that the boundaries of these reservations are still not permanently settled in every case, that new reservations are being added from time to time, and that within these reservations more or less land is owned or claimed by private parties, it is impossible at the present time to more than approximate their area.

These reservations are set aside for three important purposes: First, the preservation of the timber; second, the preservation of natural curiosities and extraordinary scenery; and, third, for the conservation of the water supply.

National parks differ from forest reserves chiefly

in the fact that no lumbering can be carried on within them; that the mining laws, except in the case of the Mount Rainier National Park, do not apply to them; that their game animals are fully protected, and that they are under the care of the troops of the regular army, assigned to that duty by the Secretary of War, but under the orders, for that purpose, of the Secretary of the Interior, and reporting to him. The best known and the largest of the national parks is the Yellowstone, with an area of 2,142,720 acres, located in Wyoming, with small portions in Montana and Idaho. The others are the Yosemite National Park (161,280 acres), the General Grant National Park (2,560 acres), and the Sequoia National Park (161,280 acres), all in California, and the Mount Rainier National Park (207,360 acres), in Washington.

The forest reservations, from the latest reports the writer has been able to obtain, are located as follows (see pages 230 and 231), and contain the areas indicated in the right-hand column, although the lands actually reserved are only the vacant public lands therein.

The President may proclaim a reservation, but it requires an act of Congress to establish a National park. Several of the reservations will become National parks in time no doubt.

State or Territory.	Name of reservation.	Date of proclamation creating reservation.	Present estimated area in acres.
Alaska ...	Afognak Forest and Fish Culture Reserve (reserved under secs. 24 and 14, act March 3, 1891)	Dec. 24, 1892	403,640
Arizona ..	Grand Canyon Forest Reserve	Feb. 20, 1893	1,851,520
	The San Francisco Mountains Forest Reserves...	Aug. 17, 1898	975,360*
	The Black Mesa Forest Reserve.....	Aug. 17, 1898	1,658,880
	The Prescott Forest Reserve.	May 10, 1898 Oct. 21, 1899	423,680
California.	San Gabriel Timber Land Reserve.....	Dec. 20, 1892	555,520
	Sierra Forest Reserve....	Feb. 14, 1893	4,096,000
	San Bernardino Forest Reserve.....	Feb. 25, 1893	737,280
	The Trabuco Canyon Forest Reserve.	Feb. 25, 1893 Jan. 30, 1899	109,920
	The Stanislaus Forest Reserve	Feb. 22, 1897	691,200
	The San Jacinto Forest Reserve.....	Feb. 22, 1897	737,280
	The Pine Mountain and Zaca Lake Forest Reserve	Mar. 2, 1898 June 29, 1898	1,644,594
	The Lake Tahoe Forest Reserve.....	Apr. 13, 1899	136,335
	The Santa Ynez Forest Reserve.....	Oct. 2, 1899	145,000
Colorado..	White River Plateau Timber Land Reserve.....	Oct. 16, 1891	1,198,080
	Pikes Peak Timber Land Reserve.	Feb. 11, 1892 Mar. 18, 1892	184,320
	Plum Creek Timber Land Reserve.....	June 23, 1892	179,200
	The South Platte Forest Reserve.....	Dec. 9, 1892	683,520
	Battlement Mesa Forest Reserve.....	Dec. 24, 1892	858,240
Idaho and Montana.	The Bitter Root Forest Reserve.....	Feb. 22, 1897	4,147,200
Idaho and Washington	The Priest River Forest Reserve.....	Feb. 22, 1897	645,120

* Even sections only.

State or Territory.	Name of reservation.	Date of proclamation creating reservation.	Present estimated area in acres.
Montana..	The Flathead Forest Reserve	Feb. 22, 1897	1,382,400
	The Lewis and Clarke Forest Reserve.....	Feb. 22, 1897	2,926,080
	The Gallatin Forest Reserves.....	Feb. 10, 1899	40,320*
New Mexico.	The Pecos River Forest Reserve.	Jan. 11, 1892 May 27, 1898	431,040
	The Gila River Forest Reserve.....	Mar. 2, 1899	2,327,040
Oklahoma.	Wichita Forest Reserve..	July 4, 1901	57,120
Oregon....	Bull Run Timber Land Reserve.....	June 17, 1892	142,080
	The Cascade Range Forest Reserve.	Sept. 28, 1893 July 1, 1901	4,588,800
	Ashland Forest Reserve..	Sept. 28, 1893	18,560
South Dakota and Wyoming	The Black Hills Forest Reserve.	Feb. 22, 1897 Sept. 19, 1898	1,211,680
Utah	The Uintah Forest Reserve	Feb. 22, 1897	875,520
	The Fish Lake Forest Reserve.....	Feb. 10, 1899	67,840
	The Payson Forest Reserve.....	Aug. 3, 1901	86,400
Washington.	The Washington Forest Reserve.	Feb. 22, 1897 April 3, 1901	3,426,400
	The Olympic Forest Reserve.	Feb. 22, 1897 Apr. 7, 1900 July 15, 1901	1,466,880
	The Mount Rainier Forest Reserve (area reduced March 2, 1899, by act of Congress creating the Mount Rainier National Park, 30 Stat., 993)	Feb. 22, 1897	2,027,520
Wyoming.	Yellowstone Park Timber Land Reserve.	Mar. 30, 1891 Sept. 10, 1891	1,239,040
	The Bighorn Forest Reserve.	Feb. 22, 1897 June 29, 1900	1,147,840
	The Teton Forest Reserve	Feb. 22, 1897	829,440
	The Crow Creek Forest Reserve.....	Oct. 10, 1900	56,320

* Even sections only.

The Yosemite National Park and other parks and reservations in California cover an area of almost 10 per cent of the State. These reservations are of great importance because of their magnificent scenery, and because of the value of the water supply in connection with extensive systems of irrigation. Stretching in an almost continuous line along the Sierra Nevada Range to the Mojave Desert is an extensive reservation which protects the headwaters of the streams which flow into the San Joaquin Valley, the granary of California. The most northern reservation in California is Lake Tahoe. It is rough and mountainous, with practically no roads and few trails. It is unfit for agriculture, and includes mountains which are never free from snow. Extending to the southward for a long distance, including some of the finest scenery of the world, is a vast tract of reserved land, including the Stanislaus Reservation, the Yosemite National Park, the Sierra Reservation, the General Grant National Park, and Sequoia National Park.

The Yosemite National Park includes the famous Yosemite Valley. A little to the southward, in the Sierra Reservation, is the Mariposa Park of Big Trees. The Yosemite Valley and the Mariposa Park are owned and managed by the State of California. They are under the control of the Governor and a

Board of State Commissioners, who are represented on the spot by the Guardian of the Valley. Although the Yosemite Region is the best known of the Sierras, the Great Sierra Reservation abounds throughout in the grandest kind of scenery. It averages in elevation from 8,000 to 10,000 feet above sea level, with many high peaks.

The following in reference to the Yosemite Valley is copied from Whitney's guide-book:

"The principal features of the Yosemite and those by which it is distinguished from all other known valleys are, first, the near approach to verticality of its walls; second, their great height, not only absolutely but as compared with the width of the valley itself; and, finally, the very small amount of talus or débris at the base of these gigantic cliffs. These are the great characteristics of the Yosemite throughout its whole length, but besides these there are many other striking peculiarities and features both of sublimity and beauty which can hardly be surpassed, if equaled, by those of any mountain valley in the world."

Near to the Yosemite Valley is the famous Mariposa Grove of Big Trees. This is only one of several groves and the only one which is surely protected. It is so called because it is situated in Mariposa County, the home of the Mariposa or "butterfly"

Indians. The Big Tree, which is known to botanists as Sequoia washingtoniana, was named for Sequoia, an Indian chief, who, it is said, was the first of Indians to invent an alphabet.

In an exceedingly interesting and valuable publication on the Big Trees of California recently is-

THE BIG TREES OF CALIFORNIA.

sued by the Bureau of Forestry, there is the following summary:

I. The dimensions of the Big Trees are unequaled.

II. The age of the Big Tree makes it the oldest living thing.

III. The majestic beauty of the Big Tree is unique and world-renowned.

IV. It now exists only in ten isolated groves on the west slope of the Sierra Nevada Mountains, and nowhere else in the world.

V. The Mariposa Grove is to-day the only one of consequence which is completely protected.

VI. Most of the scattered groves of Big Trees are privately owned, and therefore in danger of destruction.

VII. Lumbering is rapidly sweeping them off; forty mills and logging companies are now at work wholly or in part upon Big Tree timber.

VIII. The southern groves show some reproduction, through which there is hope of perpetuating these groves. In the northern groves the species hardly holds its own.

IX. The Big Tree and the smaller coast redwood represent a surviving prehistoric genus of trees (the Sequoias), once widely distributed over the globe.

Farther to the south and nearer to the ocean, on the Coast Range, is a group of reservations destined to protect the headwaters of streams which flow down into the famous region of Santa Barbara, Los Angeles, and San Bernardino. These are famous winter resorts, with a delightful climate, and with charms quite equal to the Riviera of southern Europe, but

dependent upon irrigation for the luxuriance of their vegetation. Nothing is of more vital importance to this district than water, which comes from the slopes of neighboring hills and mountains. It is, as is often said, " water not land that measures production."

In the Southwestern United States, in Arizona and New Mexico, there is a group of reservations of recent formation, the most interesting of which includes the Grand Canyon of the Colorado River. This will become in time, no doubt, a National park.

The Canyon which has been formed by the erosive action of the Colorado River is one of the most stupendous natural wonders of the world. It is 250 miles long and from 3,000 to 5,000 feet deep. Its walls have been terraced and carved by the action of water into pinnacles and towers of many shapes, the beauty of which is enhanced by a great variety of brilliant colors due to the different stratifications through which the river has cut its way. In reaching this district from almost any direction one passes through vast deserts or sandy plateaus interspersed with salt lakes and alkali tracts with little vegetation. Arizona is the land of deserts, with a hot climate, with beautiful and peculiar scenery, with petrified forests, with rich mines and with curious Indian tribes and cliff dwellings, but with little of the most important of all substances, wood and water.

The San Francisco Mountain, in the San Francisco Mountains Reservation, is a fine extinct volcano, surrounded by a district of cinder cones and lava beds. These mountains reach a height of nearly thirteen thousand feet, and are covered with one of the finest forests of the Southwest.

Extending southeastward in a long irregular shape to the New Mexican line is the Black Mesa Reservation. There it borders the Gila Reservation in New Mexico. In these reservations the headwaters of the Gila River are located. This river empties into the Colorado River at Yuma. Although it "runs dry" occasionally, it is, next to the Colorado, the most important stream in Arizona. This reservation is more or less forested. The principal cultivated regions are irrigated lands along the Little Colorado, and along the Gila River and its principal branch, the Salt River.

There is another reservation in New Mexico not far from the city of Santa Fé. It is called the Pecos River Reservation. The irrigation in practise along this river is most notable because of its magnitude. This reservation is also at the headwaters of several branches of the Rio Grande, along which for some distance there is irrigated land. It is a feeder also to the Canadian River, which empties its waters into the Mississippi via the Arkansas. The Canadian

River derives its name from the Spanish "Cañada" —a valley. It cuts deep gorges through the plateau called the "Staked Plains," and because of the red clay through which it passes its water is as red as blood. These plains are 5,000 feet above sea level, and cover an area of 50,000 square miles. The name is due, it is said, to stakes used by the Spaniards to mark their way. They are covered with grass and bushes, furnishing pasture to many herds of cattle, although water is scarce.

The small Prescott Reservation in Arizona, near the city of Prescott, was enlarged by the President October 21, 1899, at the request of the citizens of Yavapai County, Arizona, with the hope of saving the timber for the use of the immediate community. The timber thereon was being rapidly consumed by the large mines in that district. One mine alone has an output of $50,000 of bullion a day. An immense amount of timber is used for mine props in our western country. Other reservations and National parks are in process of formation in Arizona, especially in the neighborhood of Tucson, the largest city in the territory. In this town an Indian school and the Territorial University are located.

In Utah there are three reservations, the Uintah, Payson, and Fish Lake. The Uintah Reservation embraces the land on both sides of the Uintah Mountains,

with the exception of the part occupied on the southern side by the Uintah Indian Reservation. Some of the water from these mountains is used for irrigation, some of it flows into the Green River, a tributary of the Colorado, and some of it into the Great Salt Lake Valley. The first irrigation works in this country were constructed long ago by the aborigines of the Southwest. Their example was followed by the Spaniards, but the first Anglo-Saxon irrigation was practised by the Mormons.

For the beginnings of Anglo-Saxon irrigation in this country, we must go to the Salt Lake Valley of Utah, where, in July, 1849, the Mormon pioneers turned the clear waters of City Creek upon the sun-baked and alkaline soil in order that they might plant the very last of their stock of potatoes in the hope of bringing forth a crop to save the little company from starvation.

Wood is scarce in this district. The forests of the Uintah Mountains have been extensively cut, and conservative treatment is necessary in order to protect the stream sources and furnish wood for future demands.

In Colorado there are five reservations, although three are contiguous. The South Platte, Plum Creek, and Pike's Peak Reservations together form an irregularly shaped reservation between the cities of

Leadville and Colorado Springs. The other two reservations are farther westward. They are White River and Battlement Mesa. As a glance at a map of Colorado will show, they are in one of the ruggedest parts of the Rocky Mountains, and give birth to streams which flow into the tributaries of the Mississippi and the Colorado River. The vast central portion of Colorado consists of land which is unfit for agriculture but of great value because of its mineral deposits, its forests, and the water which comes from its snow-covered peaks. The Pike's Peak Reservation includes the high mountain of that name. It is one of the best known summits of the Rocky Mountains. It is 14,108 feet high, and is ascended both by a wagon-road and railroad. Small lakes in this neighborhood supply the city of Colorado Springs with water.

Northward in Wyoming and South Dakota there are four reservations, two of which are contiguous to the Yellowstone National Park. These are the Teton and Yellowstone Reservations which partake of the nature of the Yellowstone Park, of which they are practically extensions. The Yellowstone Park consists of a broad volcanic plateau 8,000 feet above sea level and surrounded on all sides by high mountains. The whole district is a scene of recent volcanic activity in the form of geysers, boiling springs, terrace

and crater formations, cañons, petrified trees, and sulfur springs. Its geysers are the finest in the world. It has beautiful lakes and waterfalls. A great portion is covered with forests, in which wild animals of many kinds are protected. The bison roams about the park without molestation, since shooting is not permitted.

Farther to the east, on the line between Wyoming and Montana, the Bighorn Reservation is located in a range of mountains of that name; and still farther east (the new Wichita Reserve in Oklahoma is now farthest east), in South Dakota, bordering on the line between that State and Wyoming, is the Black Hills Reservation. These mountains are surrounded on all sides by prairies. The conservation of the timber is, therefore, a matter of great importance. One of the most interesting natural wonders of this district is the Wind Cave. The cave is of great extent, in fact, contains miles of galleries and chambers, and a full complement of stalactitic, stalagmitic, and other formations of notable beauty. Much wood is used in the extensive mines of this district.

North of the Yellowstone Park, in Montana, there is a little reservation on the northern end of the Gallatin Range. West of it flows the Gallatin River through the fertile Gallatin Valley. It is called the Gallatin Reservation.

Westward in Idaho, Washington, Oregon, and California there is an area of perhaps 250,000 square miles called the "Columbian Lava." Through this the Snake River has cut a deep cañon, which is surpassed only by that of the Colorado River. This soil is very valuable for the production of wheat. The Yellowstone River, which flows from Yellowstone Lake in Yellowstone Park, empties into the Missouri and thence into the Mississippi. On the other side of the Great Divide the Snake River begins and flows through lava plains and plateaus of great extent. Some distance south of the town of Shoshone are the Shoshone Falls of the Snake River, where a National park has been proposed. These falls are 950 feet in breadth, and fall from a height of 210 feet.

In the far Northwest there are extensive reservations. There are two in western Montana, two in northern Idaho, three in Washington, and one large and two small reservations in Oregon. Throughout, these reservations are covered with fine timber, and the present time is none too early to institute a thorough system of protection. The four reserves located in western Montana and northern Idaho are the Priest River, Flathead, Lewis and Clarke, and Bitter Root Reservations. These are large in area, extremely rough and mountainous in nature, containing beautiful scenery and the sources of many streams

which flow eastward into the Missouri and westward into the Columbia. They are vast mountain wildernesses. Extending north and south through Oregon and Washington there is a great plateau with many snow peaks. Although an extension of the Sierra Nevada Range of California, it is called in Oregon and Washington the Cascade Mountains. On the west side the climate is mild and extremely moist, and the vegetation, which is mainly coniferous, with the Douglas-fir predominating, is extremely luxuriant. On the east side it is dry and more park-like in nature. It is used also extensively for pasturage. In Oregon the Cascade Reservation extends from the Columbia River southward almost to the southern boundary of the State. In these mountains numerous rivers flowing in both directions are fed by the melting snows. The Cascade Reservation includes a part of Mount Hood (11,225 feet), with its glaciers and cascades.

Not yet easily accessible is Crater Lake, on the summit of the Cascades. It is a huge abyss with walls from 1,000 to 2,000 feet in height, in which there is a lake of clear water with no apparent inlet or outlet. It is fresh and sweet, of a beautiful blue color, contains no fish, and is 2,000 feet deep, the deepest body of fresh water on the continent.

On crossing the Columbia, we approach the first

reservation in the State of Washington. It is the Mount Rainier Reservation, named for the famous mountain which it includes. A large area, including the mountain, is now a National park. Mount Rainier (14,520 feet), like most of the peaks of this great range, is an extinct volcano, with a crater at its summit. This mountain still emits heat and sulfurous fumes. On its sides are glaciers and cascades. Mr. Bailey Willis, in an article in the Forester, on the Mount Rainier National Park, is authority for the following:

"The first suggestion for the establishment of a Rainier National park came from two widely traveled foreigners. In 1883 they visited Mount Rainier, the one, Prof. Karl Zittel, of Munich, a geologist familiar with all the aspects of Europe; and the other, the Hon. James Bryce, a member of the English Alpine Club, and a traveler whose mountaineering conquests included Ararat. In a joint letter these gentlemen wrote:

"'The scenery of Mount Rainier is of rare and varied beauty. The peak itself is as noble a mountain as we have ever seen, in its lines and structure. The glaciers which descend from its snow-fields present all the characteristic features of those in the Alps, and though less extensive than the ice streams of the Mont Blanc or Monte Rosa groups, are, in

their crevasses and serracs, equally striking, and equally worthy of close study. We have seen nothing more beautiful in Switzerland or Tyrol, in Norway or in the Pyrenees, than the Carbon River glacier and the great Puyallup glaciers. Indeed, the ice in the latter is unusually pure, and the crevasses unusually fine. The combination of ice scenery with woodland scenery of the grandest type is to be found nowhere in the Old World, unless it be in the Himalayas, and, so far as we know, nowhere else on the American continent. . . .

"'We may, perhaps, be permitted to express a hope that the suggestion will at no distant date be made to Congress that Mount Rainier should, like the Yosemite Valley and the geyser region of the Upper Yellowstone, be reserved by the Federal Government and treated as a National park.'"

On the peninsula between Puget Sound and the Pacific, the Olympic Reservation is located. It embraces a large portion of the Olympic Mountains.

Far to the Northwest is the Washington Reserve, which borders on the Canadian frontier and includes Mount Baker (10,800 feet). It is throughout a country of such unrivaled natural beauties that spoliation of any kind whatever should be prevented, irrespective of cost.

The main point in connection with these reser-

vations and the one which needs emphasis at present, is the vastness of the interests which they subserve in the West, and the dependence of the development of irrigable arid lands upon their extension and proper administration. The great mining interests of the West are dependent upon a timber supply. In addition, there are important grazing interests which must be checked and regulated. At present the responsibility of the administration is too diffuse, and there is urgent need of consolidation and the appointment of trained officers such as Prof. Filibert Roth, the efficient chief of the new Division of Forestry of the General Land-Office.

It must not be assumed that these reservations constitute all the land owned by the Government in Western America. These are only portions of the public domain which have been withdrawn from future settlement. Neither are these absolute reservations, inasmuch as private parties still have many rights and claims; in fact, in two reservations, only every other section is reserved. The people of the United States as a whole still own a vast area in our West. Much of it is desert or so mountainous that agriculture is impossible. Much of it is used for pasturage. The percentage of vacant land, according to the United States Geological Survey, is approximately as follows:

	Per cent.		Per cent.		Per cent.
Arizona	76.08	South Dakota.	32.79	North Dakota.	47.14
Colorado	64.58	Washington .	48.98	Oregon	59.10
Kansas	1.40	California	57.83	Utah	81.89
Nebraska	22.36	Idaho	89.10	Wyoming	85.72
New Mexico	69.66	Montana	78.49		
Oklahoma	39.18	Nevada	95.30		

The Government owns, of course, immense quantities of land in Alaska. The island of Afognak has been set aside as a Forest and Fish Culture Reservation. The circumjacent rocks and waters are included. It is north of Kadiak Island, where there are Eskimo villages. It is separated from the mainland of Alaska by Shelikof Strait. This spot is of great interest because it is practically the northern limit of the coast forest of Alaska. Nothing whatever has been done with this reservation. It was set aside primarily for the purpose of establishing fish-cultural stations. The Fish Commission has never assumed control, and the taking of salmon continues regularly in violation of the President's order.

The Government has fallen heir to immense unexplored forest land in the Philippine Islands. The forestry service which was instituted by the Spanish is being continued under the efficient direction of Captain George Ahern. This region is rich in valuable woods, and there is every reason for hoping that the exploitation of the forest will

be carefully conducted. In this we may learn much from the English in India and the Hollanders in Java.

It is to be hoped also that some land may be set aside or purchased in Porto Rico for experimentation, and to furnish a place in the tropics, easily accessible, where northern students may go to study tropical vegetation. The only forest of any extent in Porto Rico which has been spared is on the mountain of El Yunque. It is only 3,200 feet above sea level, but is practically inaccessible. It is constantly bathed in moisture, and is a typical tropical mountain tangle.

There are several reasons for believing that the Isle of Pines belongs to the United States. If so, here would be an excellent place for a reservation, especially on the southern coast, before the rich virgin hardwoods are cut.

There are also large areas in the Hawaiian Islands which are worthy of preservation, and there is great need of forest planting in the Danish Islands which have just been purchased.

The most extensive State reservation is in New York, in the Adirondacks. Land has been extensively purchased by a board which was appointed by the Governor for this purpose. This region is a famous health and pleasure resort, with many beau-

tiful lakes and forest-clad mountains. Thirty thousand acres of this land have been placed in the hands of the New York State College of Forestry of Cornell University for a period of thirty years for the purpose of demonstrating the possibilities of forestry in that district. The headquarters is located at Axton, the seat of an old lumbering establishment, out of which an active forestry center is being gradually evolved.

There are two State forestry experiment stations in California, under the control of the University of California. One is at Chico and the other is at Santa Monica.

The State of Pennsylvania has begun the purchase of denuded forest lands which are the nuclei of future State reservations.

Massachusetts has spent considerable money under the direction of the Land and Harbor Commissioners in fixing shifting sands belonging to the State on Cape Cod.

Many cities throughout the United States have extensive forest parks for purposes of pleasure, and wooded areas for the collection of pure water.

The proposed McKinley National Park in western North Carolina, western Tennessee, and adjacent States, is much talked of, and there is every reason for hoping that it may become a reality in the near

future. The reasons advanced for the establishment of this park are in brief as follows:

First, the East and South have no National forest reserve.

Second, the West and North have many.

Third, western North Carolina presents every requisite for a perfect timber preserve and National park as regards climate, scenery, and timber.

Fourth, lumbermen are rapidly devastating the whole section.

Fifth, the greatest region in the United States for a variety of hardwood timber is here found.

Sixth, the region under contemplation forms the headwaters of all the streams of the Southeastern States.

Seventh, it is necessary to preserve this timber in the mountains in order to retain the water supply of these States.

Eighth, lumbering and barking will in the next few years make the establishment of a National forest preserve in this part of the country impossible.

Ninth, the region is within easy access of all the Eastern and Southern States.

Tenth, such a forest reserve would soon become stocked with game and fish; and,

Finally, it is the duty of the people of this generation to preserve such a section of the Southern

Appalachian Mountains, and to hand down to posterity a part of the country in its primeval condition.

A National park has been much talked of in Minnesota at the headwaters of the Mississippi River. These National and State parks and reservations are all in the proper line tending toward the proper end, which is complete reservation and care of all the forest land of the public domain which is unfit for profitable agriculture. In the East each State should own and properly care for such territory, as the Adirondacks, Catskills, White Mountains, etc., which is of more value for the health, pleasure, and protection to water which it furnishes than for timber, although all interests may be simultaneously subserved under judicious management.

CHAPTER XI

A LIST OF FIFTY IMPORTANT AMERICAN FOREST TREES, TWENTY-FIVE CONIFERS AND TWENTY-FIVE HARDWOODS

Any of the species mentioned below are worthy of encouragement in the regions in which they are native.

The following descriptions are selected from "Trees of the United States Important in Forestry" (H. R. Document No. 181, page 51):

Conifers

1. White Pine (*Pinus strobus* Linn.). Height, 120 feet +; diameter, 3 feet +. Northern; wide range, forming forests to Southern mountains. Best development in region of the Great Lakes. Best on light, sandy, fresh, deep soil, but successful on a large range of soils from dry to moist. Rapid grower; endures some shade; hardy. The most important conifer of the United States; good quality, however, only in centenarians. Is best mixed with deciduous trees; seed of rather slow but high percentage of germination; plant two-year-old seedlings, or sow.

2. Red Pine (Norway Pine) (*Pinus resinosa* Ait.). Height, 100 feet +; diameter, 2½ feet +. Northern; associated mostly with white pine. Great-

White Pine (*Pinus strobus*).

est development from Michigan to Minnesota. Adapted to many soils, but best quality of timber produced in well-drained sands. Extremely hardy; vigorous and rapid grower. Should be favored in Northern and Northeastern planting with white pine and deciduous trees. So far, seed very expensive and difficult to obtain.

3. Long-leaf Pine (Southern Pine; Yellow Pine; Georgia Pine; Hard Pine) (*Pinus palustris*

Miller). Height, 100 feet +; diameter, 2½ feet +. South Atlantic and Gulf States. Well-drained, loose, deep, sandy loam or gravel. The slow growth of first five years makes its silvicultural value problematic; development dependent on atmospheric moisture; least shade-enduring of pines. Rare but plentiful seeder; germinates freely; can therefore be propagated by sowing seed in permanent place. Most valuable pine of the South, but for best quality of timber requires long period of growth.

4. Short-leaf Pine (Bull-Pine; Yellow Pine; Spruce-Pine) (*Pinus echinata* Miller). Height, 90 feet +; diameter, 2 feet +. Middle Atlantic and Southern States. Best development in western Louisiana, southern Arkansas, and eastern Texas. Common on light, sandy soil. Will succeed on the poorest soil. Easily reproduced; good seeder; light-needing.

5. Cuban Pine (Slash-Pine; Swamp-Pine; Bastard-Pine) (*Pinus heterophylla* Ell. Sudw.). Height, 90 feet +; diameter, 2 feet +. Southern and southeastern coast; local in swamps and near watercourses. Best development in eastern Florida. Light, sandy soil; somewhat indifferent to drainage. Rapid grower; easily reproduced; matures seed yearly; competing with the long-leaf pine on wet sags; light needing.

6. Old-Field Pine (Loblolly Pine) (*Pinus taeda* Linn.). Height, 100 feet +; diameter, 2½ feet +.

Southeastern. Greatest development in Virginia and North Carolina. Low, moist, or dry, sandy soils and abandoned fields. Adapted to a wide range of sites. Rapid grower; light-needing; seeds persistently and plentifully.

7. Western Yellow Pine (Yellow Pine; Heavy Wooded Pine; Bull-Pine) (*Pinus ponderosa* Douglas). Height, 200 feet +; diameter, 12 feet +. Rocky Mountains to the Pacific, up to high elevation forming forests. Best developed on western slope of Sierras of northern and central California. Dry, rocky ridges and prairies, sometimes in swamps; but best in deep, loamy sand. Vigorous, rapid grower; very hardy, except when quite young. Well adapted to dry, windy, exposed places; succeeds on Western prairies. The pine for reforesting southern exposures of the Western mountain regions.

8. Sugar Pine (*Pinus lambertiana* Dougl.). Height, 150 feet; diameter, 4 feet +. Western Pacific slope. Best development in Sierras of central and northern California above 4,000 feet; lower in Oregon. Very rapid grower. Quite hardy in the East. Best pine for reforestation in its native habitat.

9. Black Spruce (*Picea mariana* Mill.; B. S. P.). Including the variety called Red Spruce. Height, 80

feet ; diameter, $1\frac{1}{2}$ feet +. Mainly northeastern, forming forests. Best development north of latitude

NORWAY SPRUCE (*Picea excelsa*).

50°. Light, dry, stony soils; much smaller in cold, wet swamps. Rapid grower.

10. WHITE SPRUCE (*Picea canadensis* Mill.; B. S. P.). Height, 100 feet; diameter, $1\frac{1}{2}$ feet +. Mainly northeastern and extending into Rocky Mountains; forming forests. Like black spruce, but probably better adapted to Western planting, being hardier.

11. Engelmann Spruce (White Spruce) (*Picea engelmanni* Engelm.). Height, 100 feet +; diameter, 3 feet +. Western mountain regions and northward; high elevation. Best development in central Rocky Mountain region between 9,000 and 10,000 feet. Dry, gravelly slopes, 5,000 to 11,500 feet. A tree for reforestation of mountain slopes along watercourses.

12. Sitka Spruce (Tide-Land Spruce) (*Picea sitchensis* Carrière). Height, 150 feet +; diameter, 6 feet +. Alaska and Northwestern coast; low elevations. Moist soil and climate, at least a moist subsoil, shady situations. Rapid grower. Probably hardy in Northeastern and Middle States, in shaded positions.

13. Balsam Fir (Balm-of-Gilead Fir) (*Abies balsamea* Miller). Height, 70 feet +; diameter, 1½ feet +. Northeastern States and northward. Cold, damp woods and swamps. Rapid grower. Valuable only as undergrowth or as nurse, and in imperfectly drained situations.

14. Douglas Spruce (Red Fir; Yellow Fir; Oregon Pine) (*Pseudotsuga taxifolia* Poir.; Britt.). Height, 300 feet +; diameter, 10 feet +. Rocky Mountain region to Pacific; wide range; forming forests. Best development in western Oregon and Washington. Accommodates itself to many soils,

but prefers a deep and moist, cool and well-drained one; succeeds well on a dry, slaty soil and on sand dunes and exposed situations. Surpasses almost all of the conifers in the rapidity of its growth, and en-

DOUGLAS-FIR (*Pseudotsuga taxifolia*).

dures much drought; shade-enduring. One of the largest and most important forest trees of the West. For eastern planting seed should be procured from Colorado or Montana. Repairs damage very readily.

15. HEMLOCK (*Tsuga canadensis* Linn.; Carr.). Height, 80 feet +; diameter, 3 feet +. Northern and Eastern States. Best development probably in

Canada. Light, alluvial loam, well-drained, but cool and moist situations. Grows slowly when young, but tolerably rapidly after four or five years; endures shade. Excellent nurse-tree for white pine, with which it is usually associated.

16. Western Hemlock (*Tsuga mertensiana* Bong.; Carr.). Height, 180 feet +; diameter, 6 feet +. Northwestern States, between 1,000 and 4,000 feet. Best development in western Oregon and Washington. A substitute for the above species on the Pacific coast. An exceedingly rapid grower, even on poor soils. Very shade-enduring, forming large part of the undergrowth in its habitat.

17. Bald Cypress (*Taxodium distichum* Rich.). Height, 150 feet; diameter, 8 feet. South Atlantic and Gulf States, forming forests in swamps and pine-barren ponds. Indifferent to imperfect drainage and flooding, but capable of rapid growth on well-drained, moist, sandy soils, and hardy as far north as latitude 39° and 40°, and even on Western prairies. Positively light-needing. To be recommended for extensive planting in favorable situations; where even superior lumber may be expected.

18. Tamarack (Black Larch; Hackmatack) (*Larix laricina* Du Roi; Koch). Height, 80 feet; diameter, 1 foot +. Northeastern. Best development in Canada on moist uplands; in United States, in cold,

wet swamps; but probably of more value when grown on deep, moist, well-drained soils, in cool situations. Rapid and persistent grower; light-needing. Deserves attention in Northern forestry, but only in mixed growths.

19. Western Larch (Tamarack) (*Larix occidentalis* Nutt.). Height, 100 feet +; diameter, 4 feet +. Northwestern; elevations between 2,500 and 5,000 feet. Best development in Valley of Flathead River, Montana. An important tree as a Western representative of the foregoing species, occupying dry slopes in dry climate.

20. Red Juniper (Savin) (*Juniperus virginiana* Linn.). Height, 50 feet +; diameter, 1½ feet +. Eastern United States. Best development in valley of Red River, Texas. Prefers a mild climate; deep swamps, borders of streams, ridges, hills; will thrive on a rather dry, loose soil. Perhaps the most important conifer for Southwestern prairie-planting, enduring drought and partial shade. Tolerably rapid grower.

21. White Cedar (*Chamæcyparis thyoides* Linn.; B. S. P.). Height, 70 feet +; diameter, 1½ feet +. Atlantic and Gulf States to central Mississippi. Most abundant and best developed in Virginia and North Carolina. Always in low, marshy, or wet ground, where it thrives well and grows rapidly.

Endures moist, upland soils, but with slow growth. Very shade-enduring; easy to propagate from seed.

22. Yellow Cedar (*Chamæcyparis nootkatensis* Lamb.; Spach). Height, 150 feet +; diameter, 5 feet +. Northwest coast region, from Mount Jefferson northward. Most common on the seacoast north of United States boundary. Like arbor vitæ.

23. Arbor Vitæ (White Cedar) (*Thuja occidentalis* Linn.). Height, 50 feet +; diameter, 1½ feet. Northeastern States and northward. Will grow well in any soil not too stiff, often forming dense, pure growths in wet, boggy swamps. Rapid grower; easily propagated; desirable for undergrowth and to fill out places where other trees fail to come.

24. Giant Arbor Vitæ (Red Cedar; Yellow Cedar) (*Thuja plicata* Don.). Height, 150 feet +; diameter, 9 feet +. Northwestern coast and from Humboldt, Cal., to British Columbia. Best development north of Seattle. Like the above species on Pacific coast.

25. Redwood (*Sequoia sempervirens* Endl.). Height, 300 feet +; diameter, 20 feet +. California coast from Oregon southward; forest-forming. Low, moist, well-drained situations and damp climate; not on dry hillsides. Vigorous and persistent grower; shade-enduring; sprouts from the stump. Highly im-

portant for California forestry; perhaps also for that of Southern States.

Hardwoods

26. White Oak (*Quercus alba* Linn.). Height, 100 feet +; diameter, 3 feet +. North Central, Cen-

White Oak (*Quercus alba*).

tral, and Eastern States. Best development on western slopes of Allegheny Mountains and valley of Ohio River. Grows well on a great variety of soils, but best on deep, moderately moist, well-drained, loamy sand, and in warm situations. Slow but persistent

grower; light-needing. Most valuable of the American oaks.

27. Basket-Oak (Swamp Chestnut-Oak; Cow-Oak) (*Quercus michauxii* Nutt.). Height, 100 feet +; diameter, 3 feet +. Southeastern. Best development on the rich bottom-lands of southeastern Arkansas and Louisiana. Moist, rich soil; will endure flooding. The most valuable of the white oaks for the Gulf States.

28. Chinkapin-Oak (*Quercus acuminata* Michx.; Houba). Height, 80 feet +; diameter, 3 feet +. Central and Middle Atlantic region. Largest growth in lower Ohio Valley. Best in deep, rich, moist, well-drained bottom-lands, but grows well and is not uncommon on dry, fertile, limestone soils; it also succeeds on clayey and sandy soils of uplands.

29. Live Oak (*Quercus virginiana* Miller). Height, 80 feet +; diameter, 3 feet +. Southern States. Greatest development in Southern Atlantic States. Warm, loamy soil, retentive of moisture, and free from overflow. One of the most rapid growers of all the oaks; most shade-enduring; evergreen foliage. Especially desirable for Southern forestry.

30. Tan-Bark Oak (Peach-Oak) (*Quercus densiflora* Hook & Arnott). Height, 60 feet +; diameter, 2 feet +. Pacific coast. Best development in red-

wood belt on California coast. Well-drained, rich soils. Shade-enduring. Foliage evergreen.

31. Chestnut-Oak (Rock Chestnut-Oak) (*Quercus prinus* Linn.). Height, 80 feet +; diameter, 3 feet +. Northeastern. Best development in Southern Allegheny Mountains. For planting on rocky banks and hillsides; never in any but well-drained situations.

32. Bur-Oak (Mossy-cup Oak; Over-cup Oak) (*Quercus macrocarpa* Michx.). Height, 100 feet +; diameter, 3½ feet +. Mainly Northeastern United States; extends farthest west and northwest of any of the Eastern oaks. Requires better soil than white oak; deep, rich loam; more shade-enduring. A Western substitute for white oak, and especially recommended for prairie planting.

33. Swamp White Oak (*Quercus platanoides* Lam.; Sudw.). Height, 90 feet +; diameter, 2 feet +. Northeastern United States. Best development in region south of the Great Lakes. In deep, moist, or inundated swamps and low banks of watercourses. Succeeds in all loose, rich, fairly moist upland soils.

34. Red Oak (*Quercus rubra* Linn.). Height, 100 feet +; diameter, 3½ feet +. East of Rocky Mountains. Most northerly of Atlantic oaks. Best development in Massachusetts. Thrives in all soils

except an undrained one. The most rapid in growth of all the oaks. Sprouts vigorously from stump.

35. Beech (*Fagus atropunicea* Marsh; Sudw.). Height, 100 feet +; diameter, 3 feet +. East of Mississippi and Missouri rivers. Best development probably on "bluff" formations of Lower Mississippi basin. Fresh, rich, but not necessarily a deep soil; limestone soils. For rocky, exposed situations. Rapid grower, enduring shade exceedingly well, and producing rich humus, which render it one of the most valuable aids in forestry.

36. Chestnut (*Castanea dentata* Marsh; Borkh.). Height, 90 feet +; diameter, 14 feet +. Northeastern and Middle Atlantic States. Best development on western slopes of Allegheny Mountains. Well-drained gravelly soils; succeeds on rocky hillsides with soil of sufficient looseness and depth; on northern and eastern exposures; will thrive on rather poor sand; slow and uncertain in stiff, clayey soil. Exceedingly rapid grower; moderately shade-enduring; sprouts most vigorously and persistently from the stump; large yield per acre.

37. Black Walnut (*Juglans nigra* Linn.). Height, 100 feet +; diameter, 4 feet +. Northeastern, Central, and Southeastern States. Best development on southern slopes of Allegheny Mountains and in bottom-lands of southwestern Arkansas

and Indian Territory. Deep, loose, fresh to moist, warm and sandy loam; will grow in a dry and compact soil, but not in a wet one. Hardy and rapid grower,

WALNUT (*Juglans nigra*).

especially in height; only centenarians produce first-class quality of wood, but useful timber may be produced in forty to sixty years. Sprouts freely from the stump.

38. SHAGBARK HICKORY (Shellbark Hickory) (*Hicoria ovata* Mill.; Britt.). Height, 80 feet +; diameter, 2 feet +. Eastern United States; wide range.

Best development west of the Allegheny Mountains. Deep, fresh soil; a compact soil not objectionable; not on poor, dry, or wet soils. At first slow, but afterward rapid grower; sprouts well from the stump. Moderately shade-enduring. Somewhat liable to injury by frost.

39. Pecan (Illinois Nut) (*Hicoria pecan* Marsh; Britt.). Height, 75 feet +; diameter, 2 feet +. Southwestern, but widely cultivated in Southern States. Best development in Arkansas and Indian Territory. Deep, rich bottom-land, but succeeds fairly on upland soils of moderate richness. Rapid grower; for Southwestern planting. More valuable perhaps for production of fruit than for timber purposes.

40. Black Cherry (Rum-Cherry) (*Prunus serotina* Ehrhart). Height, 90 feet +; diameter, 2 feet +. Eastern United States; wide range. Adapted to almost any soil and situation; best in deep, well-drained soil; will succeed also on dry soil. Very rapid grower, very soon reaching a useful size for cabinet wood. Endures considerable shade when young. The wide range of sites to which it is adapted, its rapid growth, and endurance of shade place it among the most valuable forest trees of the United States, especially for Western planting. Not infected by caterpillars in forest-plantations.

41. Sweet-Gum (Liquidambar; Red Gum; Star-leaved Gum; Bilsted) (*Liquidambar styraciflua* Linn.). Height, 100 feet +; diameter, 3 feet +. Southeastern States. Greatest development in basin of Mississippi River. Succeeds on a great variety of soils; a tree of the swamp as well as of dry soils; best on light, dry, sandy, and soils retentive of moisture. Rapid grower. Insect-proof, and generally healthy.

42. Locust (Locust; Yellow Locust) (*Robinia pseudacacia* Linn.). Height, 80 feet +; diameter, 1½ feet +. Southern Allegheny region. Allegheny Mountains; local; but by cultivation widely distributed east of Rocky Mountains. Poor, loose sands give best quality of timber; not succeeding well in compact soils, but will thrive on a thin one, and grows quickest on rich, sandy loam. Very rapid grower while young; needs light very much; sprouts persistently and vigorously from the roots. To be only sparingly dispersed among shady companions, which will afford protection against the borers. Easily propagated from seed. For short rotations and coppice management.

43. Tulip-Tree (Whitewood; Yellow Poplar) (*Liriodendron tulipifera* Linn.). Height, 120 feet +; diameter, 4 feet +. Eastern States. Greatest development in valley of lower Wabash River,

and on western slope of Allegheny Mountains in Tennessee, North Carolina, and the Virginias. Deep, light, loamy, sandy, or clayey soils, in cool, moist situations. Tolerably rapid and persistent grower. Needs light very much; hardy. Poor seeder, and low percentage of germination. Sprouts fairly from the stump. One of the largest and most valuable of the deciduous softwoods.

44. Hardy Catalpa (*Catalpa speciosa* Warder). Height, 80 feet +; diameter, 3 feet +. South Central States; rare, but widely cultivated for ornament. Best development in valley of lower Wabash River. Adapted to a great variety of soils; best on low, rich bottom-lands. Very rapid grower; sprouts vigorously from the stump; shade-enduring. Good seeder. Desirable tree for Western planting. Foliage subject to ravages of insects.

45. White Ash (*Fraxinus americana* Linn.). Height, 100 feet +; diameter, 3 feet +. Eastern; wide range. Best development in lower Ohio Basin. Depth, looseness, and moisture of soil of most importance. Best in moist atmosphere of northern and eastern exposures. Will succeed in wet and compact soil if well drained, but maintains itself with slow growth in a light and dry one. Rapid grower; light-needing, thinning out rapidly, and therefore requiring shady, slower-growing companions. Sprouts vigor-

ously and persistently from the stump. Often a poor seeder; seed not easily kept. Liable to attacks of borer and to frost when young.

46. Sugar-Maple (Hard Maple; Sugar-Tree) (*Acer saccharum* Marsh). Height, 100 feet +; diameter, 3 feet +. Eastern United States and northward. Best development in region of Great Lakes. Best on moderately deep, loose, well-drained, strong loam, and calcareous soil, in moist, cool position; will grow also on stiff clay if not too wet, and on stony hillsides if not too dry. Tolerably rapid and persistent grower; moderately shade-enduring; does not sprout well from the stump. Not well adapted to dry regions.

47. White Elm (American Elm; Water Elm) (*Ulmus americana* Linn.). Height, 100 feet +; diameter, 3½ feet +. East of the Rocky Mountains. Probably attains its best development near its northern limits. Adapted to a great variety of soils, but best on a rich, loose, moist one; requires less moisture than the ashes; bears occasional flooding. Rapid and persistent grower; sprouts well; endures moderate shade. Important in forestry mainly as a nurse and for soil cover. Recommended for Western planting.

48. Yellow Birch (Gray Birch) (*Betula lutea* Michx. f.). Height, 80 feet +; diameter, 3 feet +.

Northeastern United States and northward. Best development north of the Great Lakes. Cool, moist atmosphere preferable. Capable of thriving on poor, but best on a moderately deep, loose, moist sand; hardy and very adaptive as to soils. Rapid and tolerably persistent grower; sprouting qualities greatly dependent on site. Vigorously in moist soils. Light-needing. Easily propagated.

49. Basswood (American Linden; Bee-Tree; Lime-Tree) (*Tilia americana* Linn.). Height, 100 feet +; diameter, 3 feet +. East of the Mississippi and Missouri rivers; wide range. Greatest development in valley of lower Wabash River. Deep, moderately loose, and somewhat moist soil; can endure a wet soil, but will not thrive on a dry one. Rapid and persistent grower; sprouts vigorously from the stump; endures moderate shade. Not very hardy, but in cool situations a desirable adjunct in forestry.

50. Cottonwood (Carolina Poplar; Big Cottonwood; Necklace Poplar) (*Populus deltoides* Marsh). Height, 100 feet +; diameter, 4 feet +. East of the Rocky Mountains. Adapted to a great variety of soils, but best in a moist, strong, loamy one. Exceedingly rapid grower; sprouts vigorously from the stump; light-needing, thinning out rapidly; short-lived; readily propagated from cuttings. Has been

recommended for planting on Western prairies, chiefly on account of its rapidity of growth, ease of procuring plant material, and of propagation.

SHOOT OF CAROLINA POPLAR.
Showing vertical position of leaves.

American trees most extensively cultivated in Europe are: White pine, Douglas-fir, white spruce, locust, red oak, tulip, and black walnut.

European trees most extensively cultivated in America are: Scot's pine, Austrian pine, Norway spruce, European beech, English walnut, and Norway maple.

Some common Eastern trees which have been more or less planted, and which may in time prove of great value, are: Deodar, ailanthus, paulownia, cedrela sinensis, camphor, casuarina, candle-nut, mango, and several species of eucalyptus.

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